

The Blast Furnace *and* Steel Plant

Gauging the Capacities of Blooming Mills

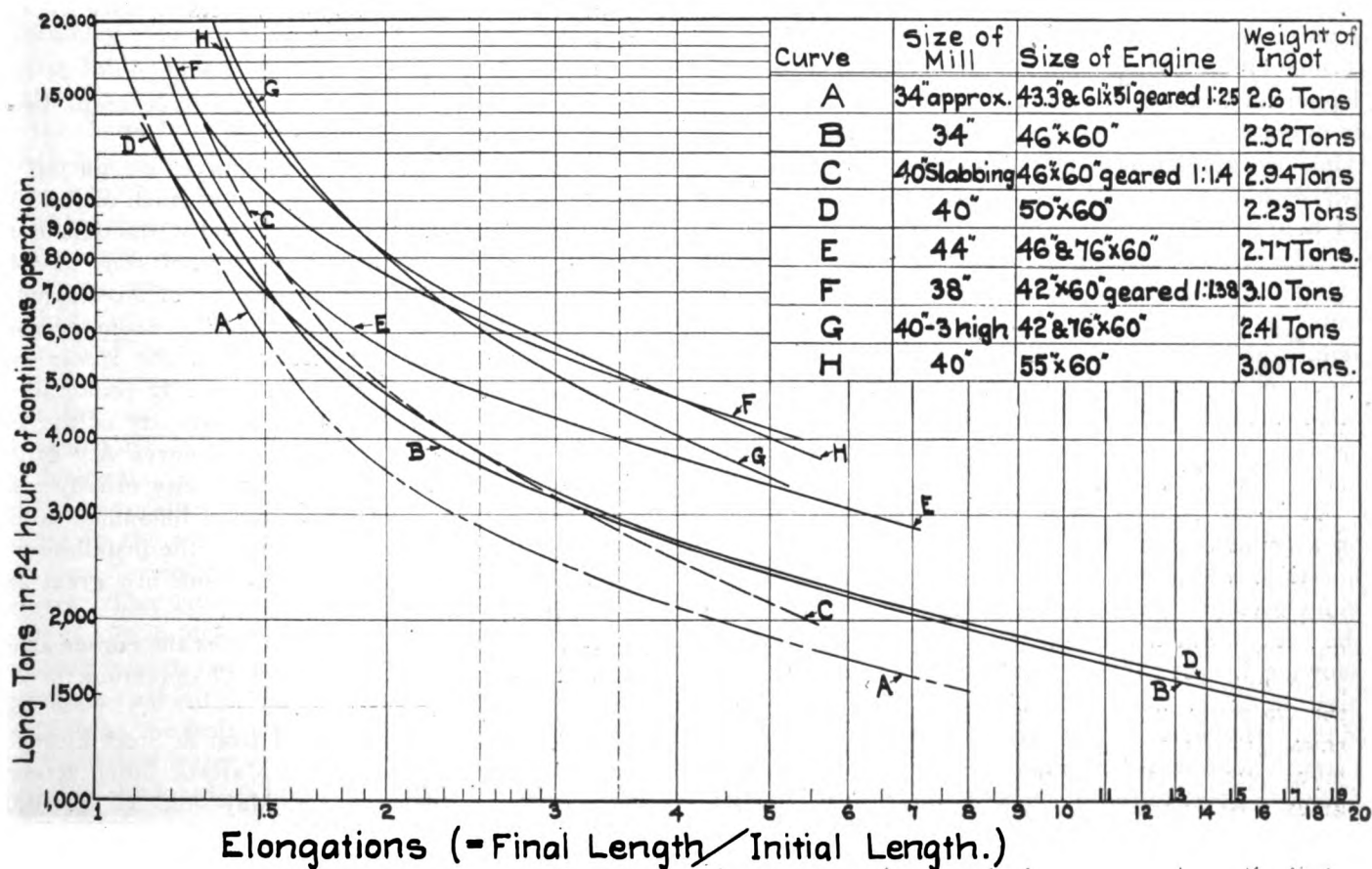
Determining the Capacity of the Blooming Mill in Respect to Other Steel Mill Equipment—Curves Showing Capacity as Related to Elongation Ratios—Influence of Ingot Weight.

By W. TRINKS.

The blooming mill limits the capacity of the steel plant more than any other one piece of equipment. Additions and changes can be made in open hearth equipment, heating furnaces and in finishing mills, but practically nothing can be done to the blooming mill, except to duplicate it.

For this reason, accurate knowledge of blooming mill capacities is very desirable. Theory does not help us any in this case, because there are too many variables. In a series of articles on rolling mill reversing engines (*The Blast Furnace and Steel Plant*, 1916), the author explained the influence of those va-

riables which depend upon the reversing engine, namely piston displacement for a given size mill, steam pressure and back pressure, moment of inertia of rotating parts, weight of reciprocating parts, size of steam and exhaust passage, volume of steam beyond control of the regulating valves, etc. But the mill proper furnishes quite a number of additional limiting features, such as roll diameter, roll length, strength of roll material, moment of inertia of rotating parts, ratio of gearing between engine (or motor) and mill, inertia of manipulator, arrangement and location of manipulator. In addition, ease of handling of motor



or engine levers, manipulator levers, screwdown levers, and of table control influences the output. Last, but not least, temperature and analysis of steel are big factors.

From this enumeration it is evident that theoretical derivation of blooming mill capacities must either be incomplete and incorrect, or too complicated to be useful. A better way to study such capacities consists in the plotting of time studies of actual mills and in investigating the principal factors producing either unusually high, or unusually low capacities of mill operation.

In the accompanying nest of curves, blooming mill capacities have been plotted against elongation ratio, on the basis of uninterrupted operation, which simply means: no delays. These capacities were obtained from the weight of ingot rolled, and from the time required to elongate it a given amount. The right hand terminal of each curve constitutes the total elongation actually given the bloom in each specific mill, whereas intermediate points show how much steel the mill could have rolled if the steel had been given fewer passes and had, consequently, not been elongated so much.

For the sake of clearness, the divisions were made logarithmic. This arrangement of divisions pulls the curves apart where they tend to bunch the closest, without making the chart unduly large.

The data were taken from many sources; they were partly taken from published data, partly from private data of steel companies, and partly from time studies made by students of the Carnegie Institute of Technology. Considering the great differences existing in mills and engines and the differences existing in operators, the values are remarkably close together. Thus we find for about $5\frac{1}{3}$ elongations, 1,800 tons per 24 hours as the lowest value, and 4,000 tons per 24 hours as the highest value.

The tonnage given in the curves is based, as before stated, upon uninterrupted operation. Actually the tonnage will be less, on account of waiting for steel, failure of the rolls to bite, raising the rolls for each ingot, changing rolls, also on account of cobbles, minor breakdowns, etc. The factor by which the ideal tonnage must be multiplied to get the actual tonnage varies from .85 to .92.

It is rather difficult to draw general conclusions, on account of the great number of variables. The question, whether geared or direct connected engines give greater capacity, cannot be decided from the curves which are here offered, because curve **A**, showing lowest capacity, and curve **F**, showing very high capacity, were both obtained from geared engines. However, a few conclusions may be drawn. First, it follows that compound engines are not conducive to great capacity; at least not for small elongations. Curves **A** and **E** refer to mills driven by compound engines. For small elongations the compar-

atively heavy masses of the compound engine, coupled with somewhat difficult control, depress the capacity of the mill. For longer passes this disadvantage of the compound engine is less pronounced. It should be noted that the capacity of a blooming mill driven by a compound engine can be increased by proper design of the engine, but it must also be realized that even then the capacity of the compound-engine-mill will be somewhat less (for small elongations) than that of a similar mill driven by simple engines. In any mill, driven by a compound reversing engine, the capacity can be increased by judicious admission of live steam to the receiver, but, if that is done, the economy of the engine is gone. Intending purchasers of compound reversing engines can save themselves a great deal of disappointment, if they carefully investigate the controlling devices of the engines offered to them.

The weight of the ingot influences the tonnage, as might be expected. The heavier the ingot, the greater is the tonnage rolled per pass for a given elongation. The two curves **F** and **H**, indicating greatest capacity, refer to mills handling heavy ingots. The latter require strong mills and strong engines or motors. Mills which break down to a 4 in. by 4 in. cannot take heavy ingots; first, because the final billet would be too long; second, because either the lift of the rolls would be too high, or else the first passes of the roll would have to be reduced in diameter and thereby weakened. Consequently, the two mills which work with almost 20 elongations show small capacity even at 5 elongations.

Curve **G** is taken from a three-high mill. It is at the top for very small elongations, but drops below other mills for greater elongations.

The author realizes that the curves do not tell the whole story. They do not tell, how much of the total time the steel is in the mill, and what fraction of the time it is on the tables. They do not state at what price of steam consumption per ton of steel some of the high capacities were purchased. From personal observation the author knows that the steam consumption per ton of steel on curve **E** could be reduced at least 25 per cent if the capacity of the mill were dropped to that indicated by curve **A**. But in times of great demand for steel capacity usually takes precedence over economy; and the blooming mill is crowded to the limit, when actually the installation of a second mill would be found to result in a great saving of fuel.

But even with these uncertainties the curves are of value to anyone interested in mill operation.

The Philadelphia section of Iron & Steel Electrical Engineers will be held at the Majestic hotel, at eight o'clock on Saturday evening, May 5th. G. E. Stoltz will talk on the subject "Some Recent Applications of Electricity in the Steel Industry."

Refractory Linings and Materials No. II

Showing Where Fire Clays and Silica Are Usable for Certain Linings—Technique and Plan of Lining Bessemer Converters, Cupolas and Ladles for Transporting Their Output.

By J. W. HAULMAN.

In going into the linings of various converters, cupolas, ladles, etc., connected with the conversion and handling of metal it is necessary to begin with the materials used for such linings, their preparation and mixtures. The most common, yet of the very greatest value, of which is clay.

Clay.

Clay is very widely distributed and familiar to everybody. It is the insoluble residue obtained after the action of water containing carbonic acid on many rocks and especially on the felspar contained in some of them. Felspar is a compound containing potash or soda, alumina and silica, it is acted upon by water containing carbonic acid, all the alkalis, (potash and soda), and a portion of the silica passing into the water as substances which are soluble and carried away with it, while the alumina and silica left from the felspar remain on the spot where the solution has taken place. This is the original method of the formation of clay in its primary deposits among rocks along whose crevices the atmospheric water has permeated. Such primary deposits often contain a pure white clay (kaolin). Such a clay is rarely found, because the conditions for its formation are rarely met with. The water, while acting chemically on the rocks, at the same time destroys them and carries off the finely-divided residues of disintegration with it. Clay is most easily subjected to the mechanical action of water, because it is composed of grains of exceedingly small size and void of any visible crystalline structure, which easily remain suspended in water. Such disintegration of rocks and separations of clay from sand have been gradually going on during the earth's existence and are still proceeding, and have been the cause of the formation of immense deposits of sandstone and clay now forming a part of the earth's strata. In places these beds of clay have, owing to long exposure under water, and perhaps partially owing to the action of heat, undergone compression and have formed rocky masses such as clay slates and schists. This latter clay which has an appearance of rock of a dark bluish color, is also found frequently in connection with coal seams and is termed a "fire clay," and upon analyzing will show approximately the same analysis as the ordinary clay, with one exception that the combined water will be 3 or 4 per cent lower than found in the loam. This clay when finely ground and mixed with water to a paste forms an excellent mortar used in connection with the laying of fire clay brick

work, the brick are dipped in the mortar and rubbed together making a brick to brick joint, the clay being equal in refractoriness to the brick itself. It is also used in mixtures with the more plastic clay to good advantage in adding to the refractoriness, but not to the plasticity of the mixture where a combination of the two qualities of plasticity and refractoriness is preferred over either for structural or mechanical reasons.

As a rule clays contain 45 to 60 per cent SiO_2 , 20 to 30 per cent Al_2O_3 and from 7 to 12 per cent combined water (H_2O). It cannot be supposed that clays are always homogeneous because they are an aggregation of residues (silico-aluminous compounds), which are unacted upon by water, although clays always contain a hydrous compound of alumina and silica. A mixture of clay and water is endowed with the property of taking a given form when subjected to moderate pressure. This plasticity of clay renders it an invaluable material for practical purposes and it is from clay that depends the lining of different vessels as well as the moulding into various shapes of brick used in linings. The plasticity of clay increases with its purity. When mixtures made of clay and thoroughly dried or baked a very hard mass is obtained. When clay is first subjected to heat its volume decreases then it begins to lose water and it shrinks still further (in case of a compact mass approximately $\frac{1}{5}$ of its linear measurement).

Fire Clay.

In the manufacture of fire brick it must be burned in a kiln at a very high temperature, as there are certain chemical changes which take place. As the clay when heated, shrinks so considerably that the form may be destroyed and cracks easily formed, such bricks are porous, but when subjected to an intense heat after a certain point has been reached a chemical change will take place which causes their grains to be bonded together. However, if the temperature becomes too great or goes past a certain point it will be over-burned and cause a porous or unsound brick. This is invariably encountered in a low grade fire clay, but where a good fire clay is low in fluxing impurities, such as Fe_2O_3 , the pores will close up slowly and the contraction will not be so rapid and a more uniform and sound brick will be obtained. It is impossible to attain a temperature in a kiln to reduce this shrinkage to a minimum, hence there will be a certain amount of contraction in the brick work lining. The analysis of a good fire brick should show approximately:

SiO ₂	50 to 55 per cent
Al ₂ O ₃	35 to 40 per cent
Fe ₂ O ₃	2 to 5 per cent
MgO	0 to ½ per cent
CaO	0 to Trace

Sand and Sandstone.

Silica, both in the free state and in connection with other oxides, enters into the composition of most of the rocky formations of the earth's crust. Silica itself is frequently found in a separate state and often forms whole masses of rocky formation, which is called quartz and when colorless and transparent is the purest form of silica. A similar anhydrous silica is often found in the transparent masses colored with various tints, and forms rocky formations. The existence of enormous masses of quartz proves that it resists the action of water. When water destroys rocky formations, the siliceous minerals which they contain are partly dissolved and partly transformed into clay, sand, etc. Common sand is generally colored yellow by foreign mineral element. Sands were formed at all periods of the earth's existence, compressed by strata of more recent formation and permeated with various substances and sometimes solidified into sandstones composing in places whole mountains and such deposits are used in the manufacture of silica brick or cut into sizes and shapes suitable for certain linings at a very low cost and used in the place of a high priced silica brick. Such stone, however, when taken out of its natural beds contain a certain amount of moisture and should be well seasoned and thoroughly dried before being used as a lining material. This sand stone or silica rock is very commonly used for the lining of Bessemer acid converters. The stone is dressed into such shapes that will turn a circle of the proper diameter. The analysis of this stone will show approximately—SiO₂—94 to 96 per cent; Al₂O₃—3 to 4 per cent; traces of Fe₂O₃ and MgO.

The lining is started at the nose of the converter, it being set in a vertical position with the nose down. The stone are keyed in from that starting point until the entire circular wall is built up. The stones are laid in a mortar made from the spalls of the same stone finely ground and a small amount of good clay added to make it plastic. Great care must be exercised to make as close joints as possible in the masonry, as the molten metal will find its way into the joints and lead to rapid destruction of the lining. Silica brick have been used as well as clay brick in the lining of acid Bessemer converters but to no better advantage than the silica rock lining and at a greatly increased cost.

In putting up a bottom section for a converter a 9 in. to 20 in. circular lining is put around the shell of the section or extended out to a circular plate through which the tuyeres are placed. The tuyeres are placed up through this plate and keyed. A layer of ganister is rammed on the plate around the tuyeres and on this

are arranged large tile brick of sufficient length to reach a level with the tops of the tuyeres, usually they are placed between the tuyeres, being the same size in width as the tuyere is in diameter, but sufficient space must be left between the tile and tuyere to allow the ganister to be rammed firmly, the tile acting as a binding agent for the ganister and a support to the tuyeres. The ganister is rammed in thin layers one upon the other, until the level of the tops of the tuyeres are reached. The bottom is then put in a drying oven and baked with a moderate heat for three or four days, after which it is ready to be attached to the converter.

The ganister used in the preparation of converter bottoms should be dry ground and is composed of a mixture of good quality clay brick bats, fire clay and swamp clay with a little coke dust. After it is thoroughly ground and mixed it is put up in a bin with enough water added to bring the moisture up to about 10 per cent when ready for use. The mixtures used should be in such proportion as to give a chemical analysis of approximately—SiO₂—50 to 60 per cent; Al₂O₃—25 to 35 per cent; Fe₂O₃ and MgO—1 to 3 per cent, and moisture 10 per cent.

Cupolas are lined generally with a 4½ in. fire brick lining against the shell and next to this another brick lining of especially designed blocks from 10 in. to 14 in. in length are placed, making a total wall from 14½ to 18½ in. On the first run on a cupola considerable of this block lining will be eaten away, this is then patched up with a silica rock similar to the stone used in the lining of converters.

For ladles used for handling of the metal from converters or open hearth furnaces, there can scarcely be any substitute offered for brick. Although a low grade of fire brick will usually answer the same purpose as a more expensive one and the brick can be protected to a great extent by putting in mud bottoms and also extending a mud lining up along the breast of the ladle where the flow of the metal from a furnace first strikes.

The May meeting of the Pittsburgh section of the Association of Iron & Steel Electrical Engineers will be held at the Fort Pitt Hotel, on Saturday, May 19th. The meeting will be in the control of the power committee, W. O. Oschmann, chairman, and the subject will be "Power Cost Accounting Systems as Practised by Steel Mills in the Pittsburgh district." The meeting will begin at eight o'clock, being preceded by a dinner at 6:30.

The spring meeting of the American Society of Mechanical Engineers will be held at Cincinnati, May 21 to 24, inclusive. Special sessions are planned for various divisions of work, together with technical excursions to various plants of interest to members of the society.

Coal and Ash Transportation at Producers

Eliminating the Human Factor in the Handling of Coal and Ashes to Steel Mill Producer Plant—Automatic Weighing and Measuring Device as Check on Fuel Used.

By H. V. SCHIEFER.

The present shortage of labor has given an impetus to the automatic handling of raw materials that has placed the subject of material handling as one that must be considered not as an afterthought, but as one of the essentials when planning almost any type of factory building. Not only the shortage of labor with resulting premium prices for same, but also the almost universal adoption of workmen's compensation laws make it not only feasible but thoroughly practical to spend large sums of money for

\$5,000 or even more for machinery that will dispense with the services of one workman. The problem resolves itself into not only a question of economic efficiency, but also in many instances into one of absolute necessity; consequently, the question of automatic handling machinery is of paramount importance, particularly so at the present time in the great iron and steel manufacturing centers where the shortage of labor is most acute.

The large steel companies are exerting all their energies to the abolishing of any manual operation and adopting mechanical devices wherever practicable. A notable example of this policy has been adopted by the American Steel & Wire Company at their Donora, Pa., plant. The problem was the handling of coal to the gas producers and the disposition of the resulting ashes. There are probably as many solutions to this problem as answers to the question, "How long is a piece of string?" but the problem was solved by the engineers in designing the plant so that both coal and ashes are handled by one operator without the use of a complicated or relatively short-lived system of elevators and conveyors.

The solution required the designing of special apparatus from start to finish, but the smooth and successful operation of the finished plant has more than ironed the wrinkles

from the brows of the engineers.

Fig. 2 shows at a glance the general arrangement adopted. A car of crushed coal is placed over the track hopper, the gates opened and the car emptied. The track hopper terminates at the bottom into a chute provided with an automatic gate which is normally closed. A drop bottom bucket is utilized for transferring the coal from the track hopper to the super hoppers located over the gas producers. This bucket is handled by means of a monorail trolley.

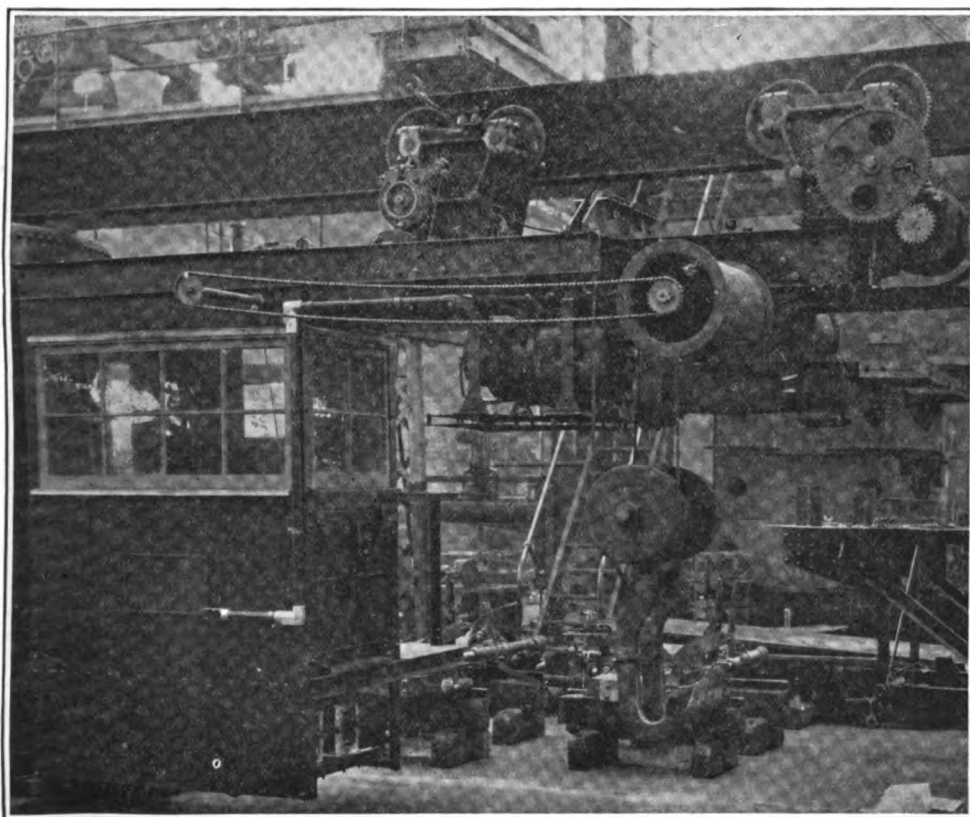


Figure 1.—Trolley specially designed for one-man ash and coal handling—Note lift indicating rigging.

automatic machinery for the elimination of the services of one workman.

In former years workmen could be had who would take any risks and work in practically untenable places and under the worst conditions. But at the present time if a manufacturer wishes to hold his men to their jobs he must not only keep the state inspectors happy, but also he must consider his workmen's minds. As a result we find that it is not an unheard of proposition for a plant manager to spend

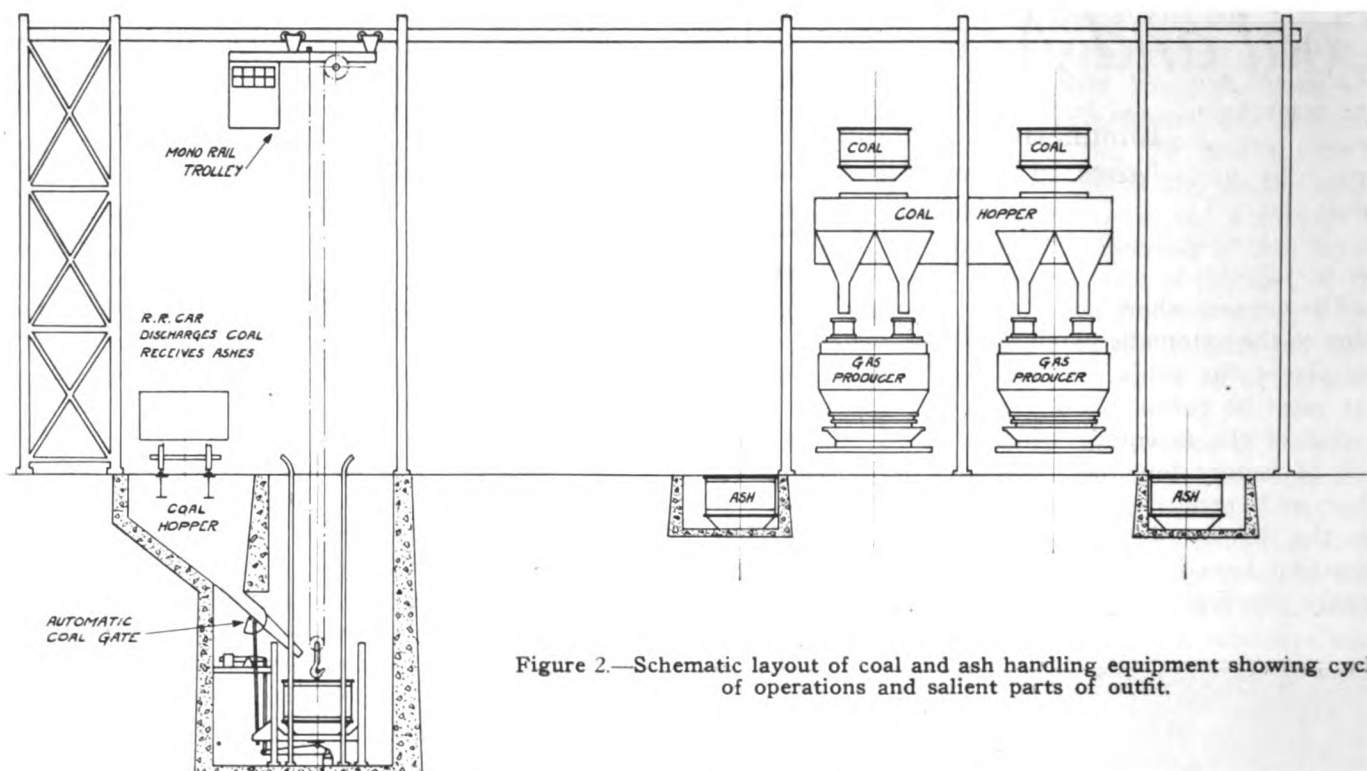


Figure 2.—Schematic layout of coal and ash handling equipment showing cycle of operations and salient parts of outfit.

This same trolley is used for removing the ashes from the pit beside the gas producers to the railroad cars, which may even be the same car from which the coal has just been removed.

This problem seemed at first to be a two-man proposition, one man in the trolley and another in the pit to operate the gate. This arrangement would have

required that a workman be compelled to enter the receiving pit each time a bucket was loaded or that he would be required to remain there, since it would be impossible to see when the bucket was properly filled. Even though stairways and ample platforms were provided, it would be impossible for a man to endure for any length of time the dust that would re-

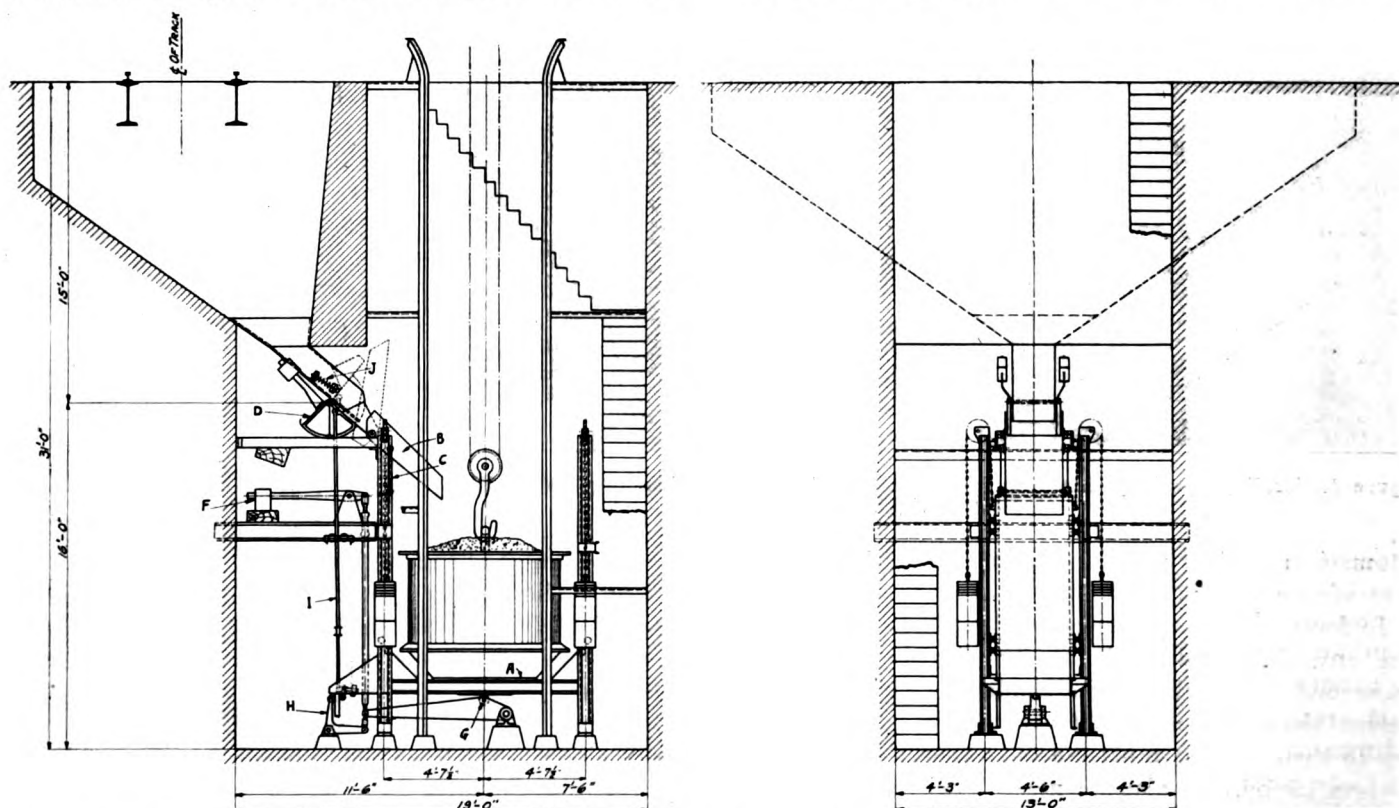


Figure 3.—Diagrammatic views of coal handling and automatic measuring device for exactly proportioning each bucketful of coal without manual assistance.

sult from the flowing and dropping of slack coal for a distance of about 10 or 12 feet. Then again supposing the operator in the pit opened the gate from the track hopper and forgot to close it. The hopper would just naturally empty itself into the pit and it would be a good day's proposition to excavate and hoist the coal.

This loading problem has been successfully solved by the designing of a combination, automatic gate and weighing device for which a patent has been applied by the engineers of The C. O. Bartlett & Snow

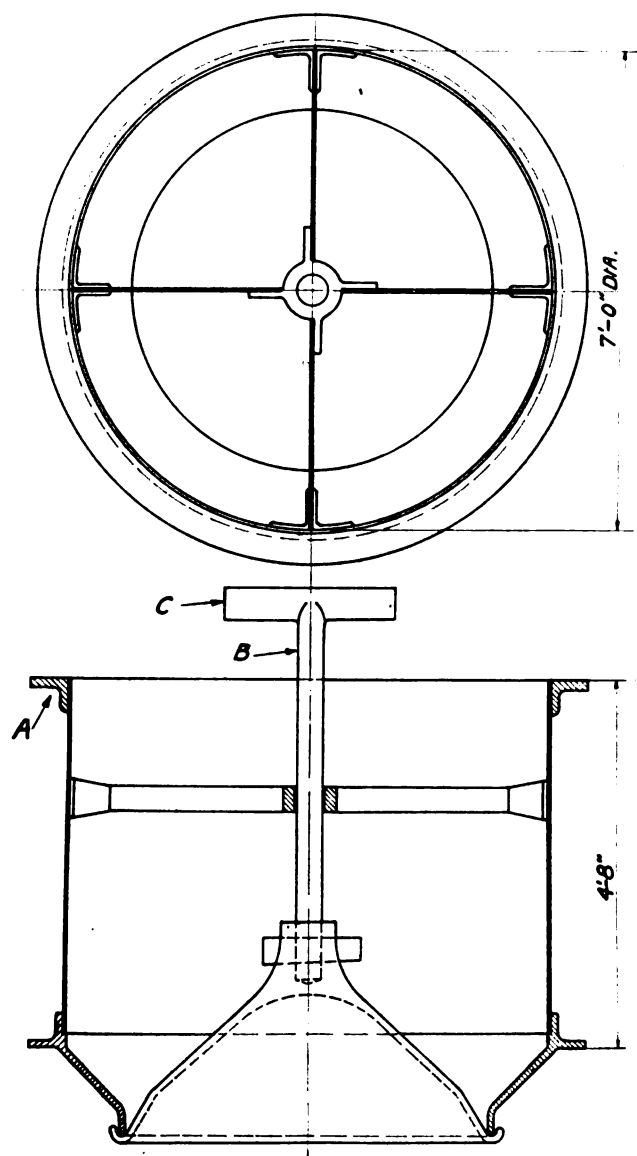


Fig. 4.—Cross-section and plan view of bucket type used on one-man fuel handling system.

Company, Cleveland. This consists in the main essentials of a counterbalanced structural steel cradle, a quadrant gate, a pivoted chute and a set of counterbalanced levers all working as a whole and in synchronism.

The empty bucket is lowered into the steel guides located in the pit until it strikes a floating counterbalanced cradle, this cradle A, Fig. 3, being in its

upper position. The weight of the empty bucket is sufficient to overcome the counterbalancing counterweights and permit bucket and cradle to descend until they rest on a set of counterweighted levers. A pivoted apron chute B is pulled into position as shown in full lines from that shown in dotted lines by means of link C, that is attached also to the floating cradle. At the same time the quadrant gate D is pulled open by means of a rod that is pulled down by a lug at E, also fastened to the floating cradle. When the quadrant gate is opened coal immediately flows into the bucket. The lever system is so proportioned that the bucket with 6,000 pounds in it and resting on the cradle and lever at G will raise the counterweight F.

When the bucket sinks the bell-crank H is actuated (due to the counterweight F rising) striking against the lever I at the point E. The lever I is hook-shaped at point E and when pushed over by the bell-crank immediately lets go of the lug on the cradle. Upon the release of this latch, gate D immediately closes, being actuated by the counterweight D and the flow of coal is stopped. The spring J acts simply as a buffer to relieve the shock incident to the closing of the gate.

The operator in the trolley above is notified automatically by the tightening of the slackened cables that the bucket is full. He then hoists the bucket, allowing the cradle to rise and the chute B is pushed back out of the way of the rising bucket.

Since the bucket always receives the same predetermined amount of coal this device resolves itself into an automatic weight recording device if a recording counter be placed so as to be operated by one of the counterweighted levers.

When the operator in the trolley sees his ropes tighten he knows he has a load and can immediately hoist his bucket and travel to a position above the coal hoppers over the gas producers and discharge his load into them. The bucket then being empty he can either return for another bucket of coal or place the empty bucket in the pit beside the producers for receiving ashes. He can then pick up a full bucket of ashes and deposit them into the railroad car that has just been cleared of its coal.

The bucket is of special design and known as a Kneeland type bucket, consisting of a steel plate side $\frac{1}{2}$ in. thick, 7 ft. in diameter, and 4 ft. 8 in. high. The bottom is a bell-shaped casting held in place by a center steel spindle fitting into another casting fastened to and forming part of the bottom of the bucket as shown in Fig. 4. The design is very similar to that used on the top of an ordinary blast furnace.

The hooks on the bottom block of the monorail trolley are made to engage the spindle of the bucket at C. The bucket is of course closed when it is placed on the ground resting on the center bell casting or hanging from the hook C. The flange A is utilized when it is required to discharge the load in connection

with a pair of large structural steel hooks placed on and operated from the trolley. To discharge the load the hooks are clamped around the flange **A** and the operator lowers on the center bell casting and the load discharges from the bucket.

The trolley was designed especially for the job by the Brown Hoisting Machinery Company, Cleveland. It is of a three-motor type, two motors for traveling and one for hoisting.

The hoisting mechanism is designed for a hook load of 20,000 pounds and a hoisting speed of 25 feet per minute with a maximum lift of 70 feet. There are four ropes so spaced that the hook can not twist when hoisting or lowering. The sprockets and chain that show so prominently in Figure 1 are used to operate an indicator placed in the cab of the trolley so that the operator can readily see at all times where his load is. The hoist is operated by a Westinghouse

motor, 25 horsepower, type K. The motor is connected to the hoisting drum by means of a worm gear reduction which materially assists in the lowering of the bucket, it being necessary only to reverse the motor. The design of the worm gear is such that it is practically self-locking.

It is generally accepted that the handling of abrasive materials with elevators is a very costly proposition. This system of handling coal and ashes as applied in this instance to gas producers could be readily applied to any number of installations where abrasive materials are encountered. It is applicable to boiler houses for coal and ashes; it would be well suited to the handling of flue dust and sinter in a Greenawalt sintering plant, in fact in almost any installation where granular materials are handled and where labor and economy are recognized as an important factor.

Mill Designs for Rolling Flat-flanged Beams

Summing Up and Concluding the Series of Articles Describing
the Various Types of Rolling Mills for Forming Flat-Flanged
Work—Limitations of Each Mill and Its Field.

By F. DENK.

In the preceding articles different types of mills for rolling flat flanged beams had been described, and it was shown that the demands made by the designers of iron structures could not be satisfied by the use of ordinary grooved rolls. Only small sections could be rolled with these types of mills, which were well adapted for mine timbering in the place of wood and for posts of small highway bridges. It was explained that ordinary two-high or three-high mills, may be used for rolling H-beams up to 8 in. by 8 in. With these sizes the practical economical limit has been reached. For larger sizes and sections the width of the flanges is limited when using grooved rolls because, in case wide flanges should be rolled, the rolls have to be of a very large diameter, which makes them extremely heavy; besides, large rolls cause a great variation in the quality of the material between the web and the flanges. It was proved by an example (see November, 1916, issue, page 513), that this variation is due to the difference in the work of reduction of the metal during the rolling process, which, in turn, is caused by the difference in speed of the various points of the groove, located opposite each other on the rolls.

For rolling large sections with wide, more or less parallel faced flanges, a universal mill with four rolls, two horizontal and two vertical ones, all lying in one vertical plane, must be considered as the simplest type of a mill, to fill the demand. With the most modern

type of such a mill, i. e., with the Puppe mill, it is possible to roll sections 40 in. deep and 15 in. wide, having flanges with parallel faces nearly all over (see April, 1917, issue, pages 149 to 152).

Such universal mills, when used for rolling these types of shapes and sections, offer several advantages over ordinary beam mills. This is due to the following conditions:

1.—Web and flanges are worked upon independently from each other. This causes a greater uniformity of the material and, therefore, a greater uniformity in strength.

2.—The flanges of the beams can be made so as to suit the conditions, for which the beam is supposed to be used, and the width is not confined within small limits, as on I-beams rolled in an ordinary mill. This results in a higher moment of inertia and a higher section modulus, referred to the neutral axis which is coincident with the centerline of the web, all in favor of the wide flanged beam.

3.—The slope can be varied to suit the conditions. In fact, this slope varies considerably with the different shapes. A Differdingen Grey-section has a slope of 9 per cent, a Bethlehem Grey-section one of 2 per cent (for both see February issue). The shapes rolled in a Sack mill (see January 1917 issue) have entirely parallel faced flanges, while the Puppe sections (see April 1917 issue) have flange faces, which slope for a short distance from the web while the other parts are parallel. (A

typical Puppe section is shown on page 150 of the April issue, a Grey section on page 68 of the February issue). The short slope of the Puppe shapes can again be varied according to demands, and thus allows a wide limit of sizes to be rolled. If, with the above enumerated conditions, the slope of a beam is compared, which is rolled in an ordinary mill with grooved rolls, the advantages of the application of universal mills for the rolling of wide flanged sections become evident.

The field of application of the beams with wide and, either partly or entirely, parallel faces, or with faces which have only a small slope, is a very extended one. They may be used as columns or posts for office and other buildings, for tipples, railroad viaducts, elevated and underground railways; they may also be applied for main bearing members and cross connections in all kinds of buildings, bridges, viaducts, etc.; they are useful as cross ties for railroad yards, wharf tracks, and as mine timbers and mine railroad tracks. The large sizes may be used to much advantage in place of built-up or riveted plate girders. Their application for this purpose saves time and money. Besides, as was pointed out above, the connection of cross beams can easily be made. All this causes a longer life of the structure.

The wide variation of sizes, in which these beams can be rolled, is also of advantage for their application. For instance, it was stated in the February issue, pp. 63 and 68, that the claim was made, that all the columns necessary for a 14 story building, can be rolled in a Grey mill with the same set of rolls, without changing the main horizontal rolls and without turning while working in the blooming mill, notwithstanding the fact, that the load varies between 350 tons in the basement and 33 tons in the 14th story. The remark, however, was made, that it was questionable from the standpoint of the designer or from an economical standpoint, if the "advantage" is really an advantage.

Of the mills described in the forgoing chapters, the following ones are, to the writer's knowledge, in use to-day:

- 1.—The Slick mill, for rolling small sizes of mine timbers etc. up to 10 inches;
- 2.—Grey mills;
- 3.—The Sack mill; and
- 4.—the Puppe mill.

All the other types have either disappeared from the market or they had not been built at all, remaining on the paper only. The reason for this condition, or at least one of the reasons, may be due to the fact, that the design of the cross sectional area of shapes is influenced not only by considerations in regard to the economy and strength, but also by conditions, which guarantee sound metal at the intersection of the web with the flanges. Naturally, an unsatisfactory design will set up at these places considerable internal stresses due to rolling, which, in connection with longitudinal shearing stresses, caused by the imposed load, will considerably decrease the carrying capacity of the beams.

To pass on the merits of the different types of mills described, or to criticize the design and construction either as a whole or in part, and to point to the advantages, which one mill may have over some or all of the others, all this lies outside of the scope of these articles, which intend only to give a sketch of the development of the mills for rolling wide flanged, flat faced beams.

Readers' Discussions.

To the Editor, **The Blast Furnace and Steel Plant:**

Referring to the article by Thomas G. Estep, Jr., on "Measuring Gases by Standard Orifice," which appears in your January and April issues. The scheme outlined by Mr. Estep in showing curves which take care of the part of the formula which is difficult to compute, is very valuable, except that for air, the curve, for practical use, should be amplified for the low differentials of the pressure, because it is almost universal practice now for the accurate measurement of air through nozzles, to employ low pressures, say from 20 to 30 in. water pressure on the high pressure side of the nozzle. This means that that part of the

curve which covers the ratio $\frac{P_2}{P_1}$ should be expanded through the range of from 1 to .94, the same as he shows for natural gas.

I also beg to point out that it would not be possible to calculate the values of "K" from the value of "N" given by Mr. Estep unless the value is given more accurately, or, unless Mr. Estep has assumed that "N" is equal to 1.4000.

In the calculation we must multiply the logarithms of the ratio by $\frac{2}{N}$ and by $\frac{N+1}{N}$ respectively, and if

we pay attention to significant figures and use four place logarithms, it is evident we must carry the value of "N" to four places. This we apparently have a right to do from the published values of "N." Professor Lucke in his "Engineering Thermodynamics," after reviewing the values of "N" by different invest-

igators, gives it as 1.4028. This value gives $\frac{2}{N}$ as

1.4257 and the value of $\frac{N+1}{N}$ as 1.7129.

From the above values, the value of "K" in Mr. Estep's formula may be computed.

F. W. O'Neil.

To the Editor, **The Blast Furnace and Steel Plant:**

In your March issue, page 124, I noticed a paragraph implying that mail order firms are working to have the second class mailing rate changed in their own interests. I personally am not interested in mail order work, but I do believe in fairness and justice, which requires that each kind of mail should pay for its own service.

It is a well-known fact that first class mail carried at two cents an ounce shows a profit of approximately 50 per cent, while on the other hand, second class mail, carried at one cent per pound in bulk, involves an enormous loss.

For example, let us take the March issue of your paper, which weighs 13 ounces and for which you claim a circulation of 6,000, about 90 per cent of which is probably distributed by mail.

The pounds mailed per year at this rate would be 52,656, upon which you would pay \$526.56 to the post-office, and upon which, according to data supplied by the postoffice, there would be a loss of about \$3,600.

Your statement that "This is just another case of an interest posing as a public benefactor, while the dear, deluded public is really supposed to turn the stone while said interest grinds its ax," thus seems to be a sort of boomerang, and in your own interest I

would suggest that you do not make the ax too sharp.

As a matter of fact, you are mistaken about the attitude of the mail-order firms, who are in reality against the one cent letter postage movement, and instead are supporting a parcel post bill with one rate for the entire country, which would mean an annual loss of millions of dollars. The Postal progress league, representing these people, evidently wants the profit on letter postage to take care of the deficit that such a bill would create.

I am not directly interested in one side of this movement one way or the other, further than that I wish to see each tub stand on its own bottom, that is, each class of mail pull its own weight by paying the cost of its distribution. I believe that upon thinking the matter over, you will agree with me that this is the only just method for a public service.

Oscar W. McKenney.

Characteristics of Electric Furnace Slags

The Function of the First Slag, or Oxidizing Slag; the Impurities Which are Removed from the Steel by This Slag; Its Characteristics and How to Obtain It.

By WALLACE G. IMHOFF.

The sequence of operations of the electric furnace for making steel fall under two main divisions based on the character of the slags. The first slag is an oxidizing slag and serves to remove the manganese and phosphorus from the steel, the second is a reducing slag and serves to cleanse the steel of sulphur.

It would seem that very little trouble should be encountered in obtaining the proper oxidizing slag but experience has shown there are many factors which render the removal of impurities from steel at times very difficult. Some of these may be interesting to look into. Among the most important factors to be studied are first of all the condition of the furnace bottom, then kind and quality of lime used, sequence of operation, control of power, and not by any means least important, the mix of the original charge.

By far the most important thing in obtaining a good oxidizing or good reducing slag is the condition of the bottom. A poor bottom will render both slags difficult to work and give an extremely large amount of trouble in all parts of the heat. The proper oxidizing slag is a thin, black, watery slag which is very easily removed by lightly scraping off with wooden rabbles. This kind of a slag is very difficult to obtain and generally the slag is inclined to be a little heavy. In small casting plants where the manganese and phosphorus limits are high and when the scrap of the charge is covered with considerable sand this slag is very easily obtained and the slag can often be removed by

simply tilting the furnace up a little and letting the slag run off. As stated before this slag is very easily made if the limits of manganese and phosphorus are high but for high quality steels when these limits are extremely low, say manganese under 0.025 and phosphorus under 0.022, sand cannot be used to thin out the slag.

There are two reasons which prohibit the use of large amount of sand to thin out this first slag, first it uses up the lime put in to reduce the phosphorus and thus the phosphorus remains in the steel even with a clean slag; second if sand be thrown in before the oxidation process has taken place then when the roll scale is thrown into the furnace it simply combines with the sand forming iron silicate with little or no oxidation and hence the final analysis shows that the manganese and phosphorus have not been removed.

Most vital of all is the condition of the bottom. With a high bottom just as soon as the steel gets hot large parts of it will float loose and come up in the slag. This renders all operation extremely difficult. In the first place the heat starts to go to the roof and walls and the furnace will "sweat" and the metal will be cold. Then when the roll scale is thrown in the slag is so heavy it is unable to reach the metal. One of the gravest difficulties encountered may be a boil on the breast. This is caused by the heavy coating of slag preventing the gases from escaping and they finally find their way to a weak place on the breast where they boil and give at times considerable trouble.

As mentioned before a slag with considerable bottom in it sends the heat to the roof and walls of the furnace and this in time lets the metal below grow cold. A very heavy viscous slag is extremely hard to slag off and with cold metal underneath, the side walls and door jambs soon become coated with cold steel which is extremely hard to remove and also cuts and tears out the lining. With a good bottom the above difficulties are removed for little or no bottom will rise in the slag to give trouble.

The next feature of importance which may make it difficult to obtain a good thin oxidizing slag is the kind and quality of lime used. This is also very important for a lime which is high in magnesium is extremely difficult to melt, hence the furnace must be run extremely hot which again puts forward the danger of bringing up bottom. The best results are obtained with a lime averaging at least 80 per cent CaO . Magnesium oxide has an extremely high melting point, hence the higher the magnesium in the lime the harder it will be to get a nice thin fluid slag. With high magnesium lime the working temperature must be kept high at all times and even then it is very difficult to obtain a thin watery oxide slag.

It is the iron oxide which lowers the melting point of slags and makes them fluid. As long as the lime is in extreme excess then the slag will be heavy and viscous but with a very large amount of iron oxide it becomes fluid. Since the oxidizing of phosphorus is a cold temperature reaction it will often be found to advantage to cut off the power completely and work the charge with a heavy steel rod. This serves two purposes, it aids the gases to escape which in escaping produce iron oxide and second the splashing throws steel into the slag which also forms iron oxide. These two features then serve to increase the proportion of iron oxide to lime in the slag and just as soon as the bath becomes quiet and most of the gases have escaped the slag will be very thin and watery. Such a slag if carried to the extreme has a tendency to cut the lining badly on slagging off so care should be taken not carry it too far. Another feature is also that it makes the metal extremely wild.

It would seem that little difference should be noted in the way the charge is worked but the sequence of operation is very important. Some operators favor the early addition of lime but the writer is opposed to this for a number of reasons. If good oxidizing conditions are required they can best be obtained by throwing scale in on the almost bare metal. This gives excellent opportunity for violent reaction serving to remove manganese, phosphorus, and carbon. While this reaction is taking place and the bath is foaming and boiling the lime is added which then can combine with the impurities removed by oxidation. In this manner the impurities may be removed to extremely low limits whereas if the lime has been added when the charge is melting down or near the end the chances for oxidation of the metal are not so good.

Another feature also is that with lime added first the charge must be melted down at a higher temperature and very often the roof and walls run considerably during the melting down stages.

The characteristic feature of oxidation is that it be carried on at a low temperature therefore the control of power is also an important factor in obtaining a proper oxidizing slag. Often the power can not be controlled as the operator would like to from the very fact that the character of the slag forces him to do otherwise.

Slags with lots of bottom in them, bad lime, or other conditions may force the use of high power until after the slag pour-off has been made but here again the difficulties of getting the metal to hat are encountered. On the one hand the slag is too cold and on the other hand the metal too hot which emphasizes the fact that metal and slag should be kept at nearly the same temperature at all times. The wider the breach between the melting point of the slag and the temperature of the metal the greater the difficulties encountered in properly working the heat.

After the metal has all been melted down the power should be cut back soon as possible. Once the metal is entirely melted very little power is required to keep it hot and therefore a minimum of power should be used in creating oxidizing conditions.

The mix of raw stock in the original charge seems also to play an important part. Some operators favor melting down very close to the carbon desired while others prefer to melt down low and recarburize to bring the carbon to the desired point. One thing seems certain, the manganese and phosphorus are harder to get out to very low limits when melting down high. The carbon seems to have more or less of a tendency to hold on to these impurities thus making their removal more difficult. In melting down low these impurities seem to come out very easily and can be reduced to very low limits.

The metallurgy of this first slag consists of a main slag composed of lime and iron oxide. This is not a chemical combination of the two but a mixture and would be represented by varying proportions of CaO and FeO .

Starting with the heat melted down we find a very thin slag on the metal composed mostly of iron and manganese oxides together with dirt, etc., which clings to the charge and has been melted up when the charge has been melted in roll scale is thrown in the bath which is for the purpose of further oxidation of phosphorus and manganese. The carbon is also oxidized at the same time and may be lowered considerably.

Immediately after the roll scale has been thrown in the lime is added. Thus lime and iron oxide go together and the melting point of the lime is considerably lowered by the iron oxide. The combination is ink black due to the iron oxide. Manganese has a tendency to color this slag brown and it may be very easily recognized.

The phosphorus is removed as calcium phosphate dissolved in the slag.

Often it is noted that after a short while the slag thickens up and would be very difficult to slag off. Bearing in mind that the iron oxide has been reduced and gone back into the steel, hence an automatic increase of lime which reaches the melting point and again thickens the slag. To thin the slag throw in a little bit more roll scale and this again brings more iron oxide into the slag and makes it fluid again. It is of little use to use spar for thinning out this slag in fact the use of spar has even seemed to make the slag thicker than before.

Where the limits of phosphorus and sulphur are very low, iron ore, simply culled hard ore, will give even more vigorous oxidation than roll scale. Roll scale is essentially a slag oxidizer while hard ore goes into the

metal and attacks the carbon, manganese, and phosphorus. The latter makes the metal much wilder and should only be used when very low carbon is desired; a roll scale will answer the purpose very well and at low cost at other times.

Care should be taken to give plenty of time for these reactions to take place. A half an hour will give good results. Roll scale should not be added just before slagging off as it makes the metal extremely wild due to the stirring in slagging off. With a good bottom an oxidizing slag will be easy to slag off and a minimum amount of steel will be lost but with a bad bottom the slag is very difficult to get off, is very heavy, thick, and exceedingly mean to handle besides keeping the steel underneath cold. Too much emphasis cannot be placed on the care of the bottom, if good results are to be obtained from either oxidizing or reducing slags.

Roll Scale for Bessemer Use: Discussion

E. T. McCleary, Youngstown, Ohio.—Perhaps there is no question before the steel manufacturers of America to-day that causes them more worry than that of maximum production, together with good quality, and Messrs. Patton and Speller have clearly shown in their excellent paper how this may be accomplished. Any

and Speller as given in their paper on this subject.

We have followed through to the finished product, heats, the temperature of which has been controlled by the use of roll scale alone, roll scale and pig-iron scrap, roll scale and steel scrap, and heats in which the temperature was controlled by use of steam blown through

TABLE 1.—Average Results from Various Tests at the Youngstown Sheet & Tube Company.

Heat	Mixer Iron			Cupola Iron			Average Iron to Vessel				Weight of Charge in Pounds			
	Total C	Silica	Mn	Total C	Silica	Mn	Total C	Si	Mn	Iron	Pig Iron	Scrap	Roll Scale	Weight
No. 1 without scale.....	4.06	1.96	0.65	3.60	1.10	0.45	3.93	1.70	0.59	25,500	None	4,000	.....	20,500
With scale	4.06	1.94	0.67	3.82	1.03	0.43	3.99	1.67	0.60	25,240	None	2,910	1,000	23,150
No. 2 without scale.....	4.04	1.97	0.68	3.64	1.06	0.43	3.94	1.75	0.62	24,420	None	4,000	.....	28,420
With scale	4.06	2.00	0.69	3.64	1.03	0.42	3.96	1.77	0.63	25,260	None	3,000	1,000	29,260
No. 3 without scale.....	4.10	1.93	0.68	3.70	1.08	0.43	4.00	1.72	0.62	24,000	None	3,985	.....	27,985
With scale	4.02	1.95	0.66	3.72	1.05	0.45	3.93	1.71	0.60	24,360	None	3,070	1,130	28,560
	Per Cent Si in Charge	Blast Pressure, Sq. In.		Time of Blow, Min.		In Min. Total Blow		Average Analysis of Slags						
								Converter Slag		Ladle Slag				
No. 1 without scale.....	1.48	23	4.70	11.00			No. 1 without scale..	Silica	Iron	Mang.	Silica	Iron	Mang.	
With scale	1.48	23	2.50	9.00			with scale	56.20	20.30	9.66	56.60	16.60	11.92	
No. 2 without scale.....	1.52	23	4.55	11.02							57.00	16.05	12.52	
With scale	1.57	23	2.50	8.80										
No. 3 without scale.....	1.49	23	4.62	10.55										
With scale	1.50	23	2.50	8.40										

It is apparent from a study of the above table that the tonnage is increased approximately 20 per cent when roll scale is used, due to the shortening of the blowing time and that the results in general agree with those shown by Messrs. Patton and Speller.

operation that tends to uniformity is certainly conducive to good practice, and as the use of roll scale in the converter eliminates to a large extent the variations in temperature due to varying silicon content in the pig iron, it should certainly give a more uniform product.

At the plant of The Youngstown Sheet & Tube Company the use of roll scale was started in the year 1908. A great many tests have been conducted as to the results obtained by its use, and our conclusions have been practically the same as those of Messrs. Patton

the molten metal, and in every case, all conditions being equal, those made with roll scale and scrap (either pig iron or steel) have given the best results.

The use of roll scale, as the authors have stated, must be a judicious one. It has been the writer's experience that the main determining factors in its use, in so far as it relates to the Bessemer process, are as follows:

(a)—The silicon content of the pig iron to be blown.

(b)—The combined and free carbon content of the iron.

(c)—The manganese content of the iron.

(d)—The initial heat of the iron to be blown.

We have found that iron with a silicon content under 1.15 per cent does not warrant the use of roll

Discussion of the paper of A. Patton and F. N. Speller, presented at the New York meeting of the American Institute of Mining Engineers, February, 1917.

scale and that it does not follow that the higher the silicon content the greater the amount of roll scale that may be used; for example, the writer has seen pig iron with 3 per cent silicon with which no roll scale at all could be used. This I believe to be due to what the practical man calls "dead iron," or, from a theoretical standpoint, iron which is low in initial temperature, low in combined carbon and undoubtedly carries a large amount of occluded gases.

The use of roll scale with iron containing over 1 per cent of manganese and the normal amount of silicon causes a sloppy blow and, quite often, steel which is not uniform. Increased silicon content of the iron tends to offset the effects of high manganese.

Table 1 shows the average results obtained from various tests made at the Youngstown Sheet and Tube Company.

H. H. Campbell, Steelton, Pa., About the year 1900, the Bessemer department at Steelton was short of scrap, and we tried using large, hard, compact lumps of ore in the converter. These were thrown in immediately after blowing began and the heavy lumps, plunged down into the molten iron. It was to be expected that they would disintegrate under sudden heating, but this same ore when thrown into the bath of an open hearth furnace did not vigorously decrepitate, so that no trouble was looked for from this source. There was no outward sign of loss at the nose of the vessel, but the deposit in the stack showed plainly that some of the ore was being projected out of the converter in particles about the size of a small pea. It is not possible to make even a guess at the loss from this cause, or to give any figure regarding the gain from the reduction of the iron in the ore, because the amounts involved were so small.

The charge of pig iron was about 22,000 pounds while the average ore addition was about 400 pounds. This ore carried about 68 per cent of iron, so that the metal in the ore represented only 1.2 per cent of the weight of the pig iron. If one-quarter of the ore had been lost, the weight of steel produced would have been only 0.3 per cent short, and we can not be sure of such accurate weighing in a small number of Bessemer heats. The slag from the vessel was normal, showing that all the ore that stayed in the converter was reduced; but it brings neither pleasure nor profit to put good ore in the vessel and then blow it up the stack.

When these experiments were made, the pig iron contained only a moderate proportion of silicon and a normal heat required about 1,000 pounds of steel scrap. At the same moment an alternate heat blown in another vessel would be satisfied with 400 pounds of ore. According to the authors of this paper, about 650 pounds should be necessary to balance 1,000 pounds of pig iron; but there is a chance for quite an error of judgment on the part of both of us. The thermal calculation involved will be left for others to investigate.

It must never be forgotten that the scrap in a Besse-

mer vessel represents a profit, for it is converted into steel without a cent of expense, except the cost of the recarburizer. Ore will furnish a little cheap metal; but 400 pounds of ore do not contain over 270 pounds of iron, and if a good part of this is blown up the stack, and if this ore addition makes it impossible to convert 1,000 pound of scrap into steel at no cost at all, then it would seem that the argument is not onesided. The experiments just cited were not pushed, and the writer did not give much personal attention to the matter. He merely suggested to the superintendent of the Bessemer department that ore should be tried, and it was used a few days on one converter. The experiment was not a failure, but the Bessemer superintendent reported that there was no particular advantage gained and so the story ended.

M. R. Stevenson, McKeesport, Pa., I am heartily in accord with the facts that have been so ably presented in this paper and from the standpoint of the furnace operator can assure you that the high-silicon iron furnished to the Bessemer Department did not work for bad practice in the blast furnace operation. Although it may require a very slightly larger quantity of coke to produce this higher-silicon iron as compared with the lower-silicon, yet the results obtained in all the succeeding departments, ending with the finished product at the tube and pipe mills, show a fairly large saving over the practice obtained with the use of lower-silicon iron.

Henry D. Hibbard, Plainfield, N. J., This paper deals with an advance in Bessemer steel practice, an art which was assumed by most steel metallurgists to have reached its highest attainable development.

The three features:

- 1.—Of using iron oxide instead of a part of the far more expensive crude iron of the charge;
- 2.—Of the greater cooling effect of that oxide as compared with scrap, thus lessening the amount of scrap needed or permitting higher silicon in the crude iron;
- 3.—Of shortening the time of blowing so as to get a greater output; are each of them important and worthy to be considered a distinct step forward in the art.

The first feature owes its value in part to the supplying of oxide of iron for the requirements of the slag instead of causing metallic iron to be oxidized for that purpose.

The second feature, greater cooling effect, comes from the absence of heat ordinarily generated by the oxidation of some of the iron of the charge and to the absorption of heat in the reduction of metallic iron from its oxide. This latter takes place to a small extent through the reducing power of the silicon while that element is still plentiful in the charge.

The shortening of the blow comes from the presence in the vessel at the start of available oxygen in the roll scale which lessens the quantity of air that it is necessary to blow in to complete the oxidizing processes.

When the basic process was being worked out about 1877, Bell tried in England the effect of adding iron ore to an acid-lined converter to see if he could maintain a sufficiently basic slag to eliminate phosphorus from the iron. He added so much ore that the ganister lining of the vessel was badly scorified, and an excessive quantity of slag was made which contained so much silicic acid that no phosphorus was taken from the metal. The experiment failed and no further trials were made on that line.

The calorific effects of oxidizing the commonly determined elements in crude iron by magnetic oxide of iron or roll scale at 1,350 deg. C., which may be taken as the temperature of the charge at the beginning of the blow, are given approximately in Table 1.

TABLE 1.

Element	1 Kg. Oxidized to	Heat of Combustion, Calories	Heat Consumed, Calories	Heat Lost in Gases, Calories	Surplus, Calories	Deficit, Calories
Silicon.....	SiO ₂	7,595	4,836	.....	2,759	.....
Phosphorus	P ₂ O ₅	5,892	5,642	.....	250	.....
Manganese.	MnO	1,653	1,612	.....	41	.....
Carbon.....	CO	2,430	5,674	1,169	.....	4,413
Carbon.....	CO ₂	8,100	11,348	3,270	.....	6,518

One kilogram of iron burned by oxygen to Fe₂O₃ gives 1,612 Cal. The "heat consumed" column gives the heat spent in reducing enough of the Fe₂O₃ to give the quantity of oxygen required for each reaction considered.

In the Bessemer works at Steelton the cooling effect of ore in the converter was years ago found to be three times as great as that of an equal weight of scrap, which is about the proportion found by calculations. That is 100 kg. of ore absorbs about 105,000 Cal., while 100 kg. of scrap absorbs 37,000 Cal. in melting.

The table explains why the silicon is the chief heat producer of the acid process and why its heating power is decreased to little more than a third when it gets its oxygen from Fe₂O₃ instead of from air. It also shows the great heat absorption in the reaction of carbon on Fe₂O₃ by which metallic iron is reduced.

The benefit from the lessened cost per ton of ingots is, in times of great demand, like the present, overshadowed by the profit on the increased production secured. For a dime saved in costs a dollar is made in profits.

C. S. Robinson, Youngstown, Ohio., Mr. McCleary's paper is not conducive to much discussion, but it is a very pleasant thing to be able to so thoroughly corroborate the main points brought out in the paper of Messrs. Patton and Speller. Referring to what Mr. Stevenson has said, it seems to me that the range permitted in the analysis of pig iron is such that it enables the blast-furnace man to make more pig iron, suitable for the purpose, and also that he makes a greater amount of a good grade on a more acid slag at a somewhat less cost. He has to carry less lime and he gets into fewer difficulties in his operations, thus working to a more uniform steel due largely to the use of scale; and this is reflected in the welding properties of the skelp and the general quality of the pipe formed from such steel.

J. W. Richards, South Bethlehem, Pa., It is extremely interesting to hear the details of this application of the open-hearth ore reaction in the Bessemer converter. It undoubtedly functions by limiting the amount of air which is necessary to oxidize the iron, and thus limits the length of the blow, and the heat losses by radiation during the blow. There seems to be, however, a contradiction which I hope will be solved by a study of the conditions. The reaction of the scale upon the iron must undoubtedly be a reduction of the scale by the silicon in the iron. Whether the scale is reduced to ferrous-oxide or to metallic iron, its reduction by silicon is an exothermic reaction, against which you have only the heat necessary to raise the scale to the reacting temperature which is a much smaller amount of heat than is evolved. I cannot, therefore, imagine why the use of the scale should have one and a half to three times the chilling effect of putting in cold scrap. There is some contradiction here which needs to be cleared up by a further study. Then there is the further great saving the heat otherwise carried out by the gases. The heat lost by the nitrogen of the air, which would ordinarily do the oxidation, is entirely suppressed and that is an enormous factor. Therefore, I think that when we get the heat balance straightened out, it will be found that the use of the scale is not in itself a chilling reaction. I think it must be an exothermic reaction, the silicon of the iron being the reducing agent in such a reaction.

A. Patton., Prof. Richards questioned the loss, or the difference between that which goes into the bath as Fe, and that which is lost as an oxide or combined iron in slag; that is, a part of scale used, is not accounted for. As Mr. Speller has told you, the combined iron in slag is just about the same, regardless of whether scale is used or not. Now if we use, say, 1½ per cent of charge (metallic) scale, that probably will take care of the combined iron in slag. If 3 per cent is used, then there must be 1½ per cent, or half of your scale used, that is taken care of and reduced to Fe. We do not know, of course, whether the scale goes with the slag as combined iron and takes the place of what we would make to satisfy this slag if the scale was not used, but one will offset the other, as we find that the iron in the slag is just about the same when the scale is not used as when it is used, so in this way you can find that we recover practically all the iron in the roll scale as Fe.

J. W. Richards. In that case, I must object to the statement of the chilling effect of using the scale, because the heat reactions show that the reduction of the scale to metallic iron by silicon and the formation of the silicate slag provides considerably more heat than would be necessary to raise the scale to the reacting temperature. There is some contradiction here which needs to be straightened out by more practical information.

Impact Tests and Their Relation to Others

Comparison of Results Obtained from Various Types of Machines for Testing Resistance to Impact, Torsion and Other Stresses of Steels of Various Analyses—Tabular Stress Data.

By HOWARD J. STAGG, JR.

The early history of physical testing indicates that the methods employed and the apparatus used were extremely crude. Indeed, not much progress was made until between the years 1835-1840 when we began to hear of the first steps and beginnings. Most of the early pioneer work was done in England and the results of the work of the British Commission, and such Englishmen as Elton Hodgkinson, Peter Barlow, Sir William Fairbairn, and others began to attract considerable attention about this time. The work of David Kirkaldy (about 1860) brought to the notice of engineers throughout the world that ductility plays an important role in wrought iron and steel. At the same time the influence of this work tended to contradict the idea that tensile strength was the only important item to be

and Captain T. J. Rodman. Next to this came the work done by the various iron companies, very little of which was ever published.

However, the year 1875 marked the first noticeable step toward real testing in the United States, for it was in this year that the large 800,000 pound Emery testing machine was constructed at the Watertown Arsenal, an event which marked the end of the early period and the beginning of a bigger, broader, more scientific era. A marked impetus was given to all kinds and methods of testing.

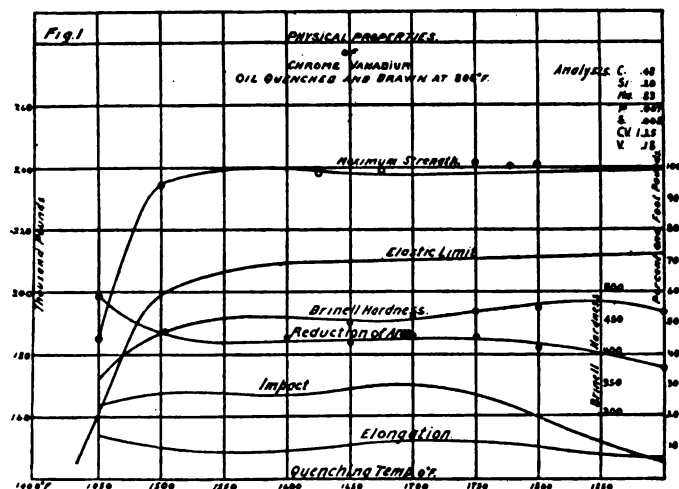
Bending tests by impact have been recommended in the past by many investigators. As early as 1892 they had reached such a stage of improvement that Le Chatelier advocated such tests before the French committee on methods of testing, and work has been done on nicked bars by Barba, Considere, Le Blaut, Aucher, Frémont, Oswald, Charpy, Russell, Thomas, McAdam, and many others. Many of these investigators sought to determine the resilience by impact tests as a substitute for the ordinary tensile tests. Impact testing, however, has been surrounded by so many variables that it has never been found absolutely and entirely practicable for structural materials. Taken in connection with other tests, they are of value, but alone, doubtful.

Perhaps it would be well to inquire as to the nature and mechanism of impact tests. (I take verbatim a quotation by M. Cornutt, Bulletin Soc. D' Encour, February 1901.)

"If we suppose a piece of steel, iron, etc., is submitted to a continuous effort, slow and progressive, one understands perfectly that this persistent effort is transmitted successively from molecule to molecule in such a way that all the molecules of the body are sensibly submitted to the same effort. In the case on the contrary, where the effort is sudden, instantaneous, one understands that all the molecules of the body do not have time to distribute the force, and that the first molecules touched can be torn apart, while the other molecules would sustain no apparent shock. Metals can then present different qualities when they are submitted to slowly applied forces or to suddenly applied ones."

Of the impact testing machines there seem to be three general types in use to-day.

A—A drop test in which a tup of varying size and weight is dropped from an arbitrarily predetermined height upon the center of a test piece, which is supported in a suitable manner at each end. A testing

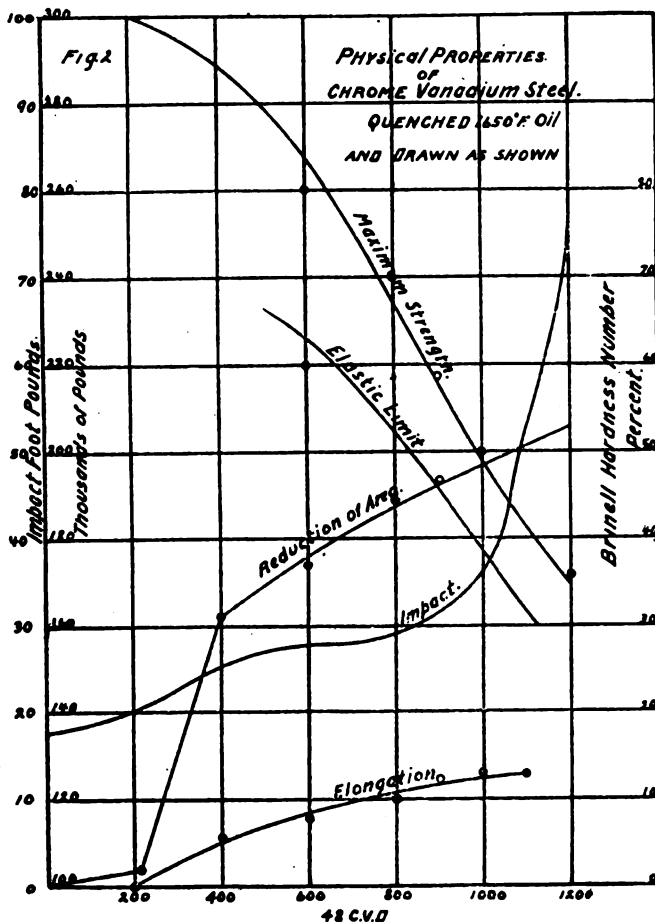


considered when judging the relative value of materials of construction. This was especially true in regard to boiler plate, for previous to this date, material was usually purchased under a brand name, with no attempt to use general specifications. We can safely say that at this time was born the idea of standard specifications for materials, the rapid growth of which is evidenced in our day by the wonderful work which the Standards Committees of such organizations as the International Association for Testing Materials, the American Society for Testing Materials, The Society of Automotive Engineers, etc., have done. In the United States the greater portion of the early work of testing was done either by or for the government, and mostly on cast irons, as is shown by the researches of Major W. Wade

Address given before the Steel Treating Research Club of Detroit, Mich., by the author.

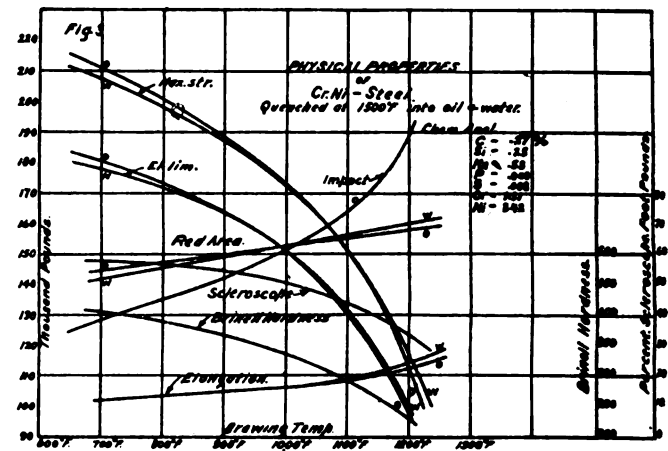
machine of this type is similar to the well known pile drivers, with the exception that instead of dropping upon a pile the tup hits the center of the test piece. This type of test was developed by Frémont, and the machine, as usually constructed consists of a tup weighing 10 Kilos or 15 Kilos, with a knife edge, falling through a distance of 4 meters and striking the test piece in the centre. The energy remaining in the hammer after the impact is usually measured by the compression of a spring. This is not very accurate, and Amsler in 1904 constructed a device which graphically indicates the velocity of fall immediately before and after

energy is consumed which shortens the swing of the pendulum. The angle through which it does swing is measured and the difference between the angle of the full swing and the impeded swing is a measure of the



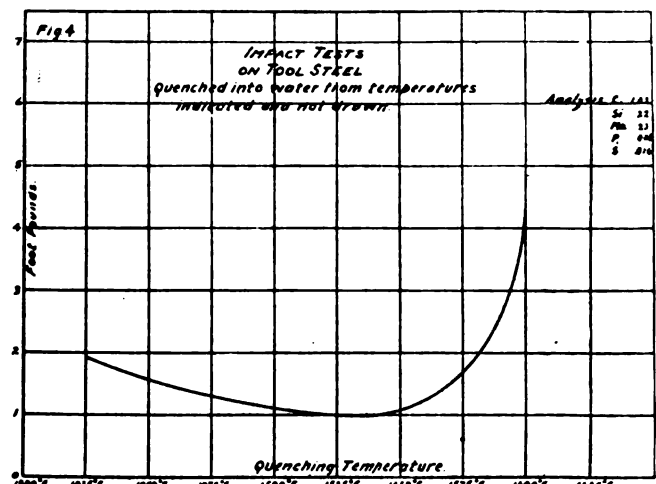
fracture. The work done in falling is then deduced.

B—I.—A pendulum machine of which the Charpy is an example. In this machine a pendulum of known weight is swung through an arc from a known height and the knife edge of the pendulum strikes a test piece at the bottom of its swing. Generally a nicked test piece is used, and is so placed that the pendulum strikes the unnicked edge directly behind the nick. Each end of the test piece rests against a support of the machine. When there is no test piece in the machine and the pendulum is raised and released, the pendulum develops a certain number of foot pounds of energy which is registered on a scale attached. When, however, the test piece is inserted the pendulum swings, hits, and breaks the test piece and then continues through its swing. In breaking the piece, a certain amount of



energy required to break the piece. The machine can be so calibrated as to give a reading of the number of foot pounds or kilograms absorbed directly, and this is usually done.

B—II.—A pendulum machine of the Izod type. This machine is somewhat similar to the Charpy machine. A pendulum of known weight drops from a known height and develops a certain number of foot pounds. The pendulum strikes the test piece and the amount of energy absorbed is measured. The manner of holding the test piece, however, differs from that employed in



the Charpy machine. One end is clamped perpendicularly and tightly in jaws with the nick of the test piece protruding just above the clamps. The other end of the test piece extends free above the clamps. The nick in this case faces the pendulum.

C.—A rotary hammer impact machine of which the Guillery is an example. In this machine a small steel flywheel carries on its rim a knife intended to break the test piece. After impact, the energy absorbed in breaking the test piece is calculated from the variation

in the speed of the flywheel at the moment of rupture.

It might be well to mention, also, that Impact tensile tests have been made and are being made. Prof. Martens was the first to use this type of apparatus, and Mr. W. P. Wilikhow has presented some rather recent data before the International Society for Testing Materials. The apparatus consists of a test piece, one end of which is held in an upper and the opposite end in a lower tup. By a suitable arrangement both tups and the test piece are released and the upper tup is arrested in its fall, thus causing the moment of the lower tup to exert sufficient energy on the test piece to pull it apart instantly. The residual energy in the free tup after rupture is measured by the compression of coiled springs, and from this data the energy of rupture is calculated.

The numerous tests which have been carried out do not appear to indicate a marked superiority in any

was 10 mm. square, 40 mm. long, the nick at the centre 1 mm. wide, 2 mm. deep, and the bottom cut to a radius of 1/2 mm. The test pieces were ground to size after treatment.

The tensile tests were run on an automatic and autographic tensile machine of 100,000 pound capacity. The standard .505 inch round, 2 inch long test piece adopted by the A. S. T. M. and S. A. E. was used.

The Brinell hardness tests were run by using a ball 10 mm. in diameter and with a load of 3,000 Kilos, applied 30 seconds.

All heat treatments were made by bringing to the desired temperature in an oil fired furnace, holding at temperature 5 to 10 minutes and quenching into the medium mentioned until cold. All drawing was done in a liquid bath of either oil, a mixture of potassium and sodium nitrates, or lead, as the temperature required, and were held at this temperature for 25 to 30 minutes.

All tensile tests are the average of closely agreeing duplicates.

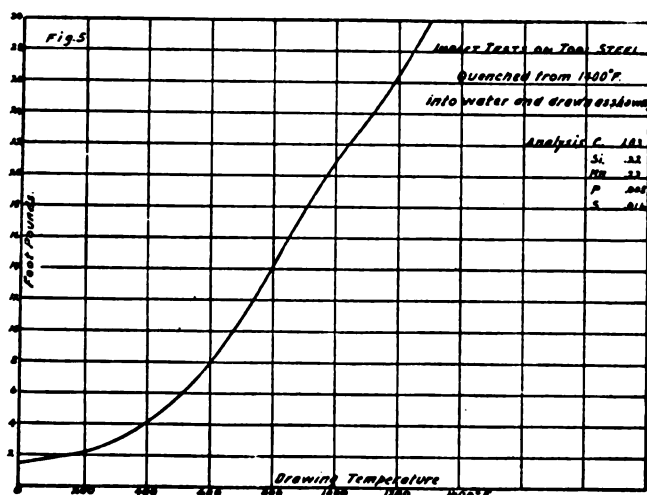
All torsion tests are the average of closely agreeing duplicates.

All Brinell Hardness figures are the average of 4 tests—one test on the unstressed portion remaining at both ends of each tensile test piece.

All Impact tests are the average of tests made on 4 tests specimens.

The torsion tests were run on an automatic and autographic torsion testing machine, 230,000 pounds capacity. test pieces 1 inch in diameter being used, with a distance of 16 inches between the grips machined and ground to a finish. Unfortunately, although run on the same types of material, the torsion tests were not run on the same heats of material as in the Tension and Impact tests.

The curves shown on Fig. 1 and Fig. 2 represent the tensile, Brinell and Impact figures of a .48 Carbon Chrome Vanadium Steel of the analysis shown, and are plotted from the data given in table 10, Fig. 1, showing the physical properties developed when steel of this analysis is quenched from an ascending series of temperatures—1450 deg. F. to 1900 deg. F.—and all drawn at 800 deg. F. for 25 minutes. It will be noted that the elastic limit and maximum strength of this steel are rather low when quenched at temperatures below 1500 deg. F. Also that the elongation and reduction of area are somewhat higher, as the temperature of quenching rises. These curves are practically straight lines up to 1800 deg. F. where a very slight falling off in the values of the elongation and reduction are noted. The elastic limit and maximum strength, however, show little or no deviation; likewise the Brinell hardness curve. The Impact curve, however, gradually rises until a temperature of 1650-1700 deg. F. is reached. At 1750 deg. F. a marked falling off is noted and at each successive rise in the quenching temperature this falling off becomes more and more evident. At 1900 deg. F. the



one of the various methods used in testing notched bars by impact. Hence no particular one is recommended to the exclusion of any of the others. Each type of machine is championed or used by some investigators, and the arbitrary results recorded. The very fact that no standard has been adopted has rendered the correlation of existing data extremely difficult and indefinite, and it is indeed almost impossible to translate the figures of one worker into those of another.

In the actual data to be presented the writer makes no claim of originality of method, makes no suggestions, nor claims that the impact work as presented can be translated into terms of the Frémont, Charpy, or other machines.

In making the Impact tests, a pendulum machine having a tup weighing 33 1/3 pounds and falling from a height of 3 feet, developing a blow of 100 foot pounds, was used. One end of the nicked test piece was held tightly in the jaws, with the opposite end projecting free above. The bottom side of the nick was about 3 or 4 thousandths of an inch above the gripping jaw with the nick facing the pendulum. The standard test piece adopted by the S. A. E. and A. S. T. M. was used. It

impact figure has dropped to 7, while at the temperature which is recommended for quenching this material, 1650-1700, it had an impact figure of about 30. In this instance, you see, information has been given us which both the tensile and hardness figures failed to detect markedly. Fig. 2 shows the physical properties of this same steel when quenched from 1650 deg. F. into oil and drawn at an ascending series of temperatures from 0 deg. F. to 1200 deg. F. Due to the fact that the elongation and reduction of area figures were so low at temperatures below 600 deg. F. the extensometer was removed from the test piece during tension and consequently the figure of the elastic limits at temperatures below 600 are missing.

It is to be noted that the elastic limit, maximum strength and Brinell hardness tests decrease uniformly with increasingly higher drawing temperatures and that the elongation and reduction of area figures also increase rather uniformly. The Impact curve rises rather uniformly up to about 800 or 900 deg. F. but a marked and undeniable deviation occurs at these temperatures and shows unmistakably that the best condition for resistance to Impact occurs at drawing temperatures higher than 900 deg. F. While the elongation and reduction of area figures show this to some extent, they fail to show it in so marked a degree as the impact test itself does.

Fig. 3 shows the physical properties of a .27 carbon, 1.31 chromium, 3.42 nickel steel when quenched into oil, and also when quenched into water and drawn at a series of ascending temperatures. The general characteristics of the curves are similar to those shown before, but in this case the impact figures exhibit a more gradual increase. It does, however, indicate that there is an increasingly greater ability to resist shock as the temperature rises, and furthermore shows it to a greater extent than either the elongation or reduction curves.

The writer has not plotted all the curves of all the alloy steels shown but has simply submitted in tabular form a few results, all of which, if plotted, would be of the same general character.

An impact number corresponding to certain physical properties developed by a certain heat treatment in one steel compared with the impact number obtained in a different steel does not usually represent the existence of the same physical properties in the other steel. For example, as indicated in table 7, an impact figure of 42.4 corresponds to an elastic limit of 53,500—maximum strength of 104,000, elongation of 22.5 per cent, reduction of area 48.0 and Brinell Hardness of 189, while this same Impact figure 42.3, as indicated in table 4, corresponds to the following physical properties: Elastic Limit, 172,000, Maximum strength, 200,000, Elogation, 16 per cent, Reduction of Area, 56.5 per cent, Brinell, 380. In other words there seems to be, as Leon and Ludwick say, "no uniform relation existing between static tensile tests and notched bar impact tests."

Figs. 4 and 5 are plots of a tool steel 1.03 carbon

with no alloy. Fig. 4 shows this material quenched into water at increasing temperatures. The test piece, 10 mm. square, was hardened throughout and the fracture of the properly hardened test pieces was fine, refined and silky to the center. You will note also that the ordinate figures cover only a range of from 0 to 7 foot pounds. In other words, the resistance to Impact of tool steels which are hardened and not drawn is extremely small. At 1400-1425 deg. F. the material hardened well and exhibited a beautiful fracture. At increasingly higher temperatures the grain became "drier" until at 1550 and higher a coarse and coarser crystalline fracture was obtained. The curve shows a straight line at the correct hardening temperatures and decreases perceptibly up to 1550 deg. F. At 1550 a marked and unmistakable change in the slope takes place and the resistance to impact, strange to say, increases. This is true and is a fact for the writer has run this series of tests on 6 different types of tool steels, including those containing vanadium, tungsten, chromium in varying proportions, and also on two different carbon contents in each class of tool steel. Why it is true the writer is unable to state, but he gives it to you for what it is worth.

Fig. 5 represents the same tool steel quenched from 1400 deg. F. into water and drawn at successively increasing temperatures. The slope of the curve increases with the temperature and indicates one of the reasons why a hardened tool should have its temper drawn. It is curious to note the change in the slope at the transition point between file hardness and file softness—400-450 deg. F.—denoting an increased ability for resistance to impact, upon becoming softer.

The torsion tests were run on 1-in rd. bars, with 16-in. between grips. Tensile figures in the torsion experiments were procured by machining standard tensile test pieces from the unstressed portion of these same test pieces after rupture. There is nothing to note particularly, except that the general character of the torsion curves follows that of the tensile, but are much lower. For instance, the average ratio of elastic limit in torsion to that in tension in the case of 42 tests, heat treated as for shafts, was 64.3 per cent. The average ratio of maximum strength in torsion to that in tension in the case of 42 tests, heat treated as for shafts, was 87.5 per cent. The average ratio of elastic limit in torsion to that in tension in the case of 24 tests, in the annealed condition, was 56.4 per cent. The average ratio of maximum strength in torsion to that in tension in the case of 24 tests, in the annealed condition, was 84.7 per cent.

There seems to be no fixed ratio between either the elongation or reduction and degrees twist per inch.

In conclusion, the writer wishes to point out and emphasize the fact that isolated Impact Tests used alone are misleading, but that by using them as a supplement to the data obtained by other methods of testing, they give us extremely useful and valuable information.

TENSILE TESTS OF 3% PER CENT NICKEL STEEL—TABLE 1.

Analysis—C., .20; Si., .18; Mn., .69; S., .013; P., .007; Ni., 3.59.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
160,000	198,000	12.5	41.5	354	49	1550 oil 212
145,000	193,000	11	45.6	356	46.4	1550 oil 400
125,000	150,000	15.5	68	264	70.4	1550 oil 800
95,000	115,000	20.25	73	216	82.8	1150 oil 1000
55,000	79,000	31.0	64.7	143	75.3	Annealed

TENSILE TESTS OF 3% PER CENT NICKEL—TABLE 2.

Analysis—C., .36; Si., .15; Mn., .73; S., .007; P., .011; Ni., 3.70.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
171,000	185,000	14.5	61.2	342	80	1500 oil 800
200,000	220,000	12	57.5	429	33.3	1500 oil 800

Ni., 3.99.

TENSILE TESTS OF CHROME NICKEL STEEL—TABLE 3.

Analysis—C., .11; Si., .21; Mn., .38; P., .008; S., .008; Cr., 1.62.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
169,500	187,000	14.2	61.0	302	85	1550 oil 212
157,000	176,000	15.0	64.3	298	85	1550 oil 400
160,000	178,000	14.75	63.8	298	81	1550 oil 600
79,250	131,500	19.75	67.0	220	86.6	1400 oil 600
129,000	178,000	14.75	63.6	298	81.3	1500 oil 600
160,000	179,000	14.25	63.1	298	80.1	1700 oil 600
158,500	179,000	15.25	62.5	289	80.3	1900 oil 600
168,500	161,500	13.50	60.1	302	86.1	1150 water 212
160,000	180,750	13.50	63.7	302	87.9	1550 water 400
160,250	180,750	13.50	63.75	289	83.1	1550 water 600
151,500	165,250	14.50	66.7	285	86.7	1550 water 800
52,500	124,500	23	60	198	82.8	Annealed

TENSILE TESTS OF CHROME NICKEL STEEL—TABLE 4.

Analysis—C., .27; Si., .25; Mn., .55; P., .009; S., .008; Cr., 1.31.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
180,000	214,000	12.0	53.0	418	37.4	1550 oil 600
172,000	200,000	16	56.5	380	42.3	1550 oil 800
150,000	173,000	17	63.0	350	62.0	1550 oil 1000
100,000	113,000	23	66	260	over 100	1550 oil 1200

TENSILE TESTS OF CHROME NICKEL STEEL—TABLE 5.

Analysis—C., .38; Si., .17; Mn., .51; P., .009; S., .009; Cr., 1.01.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
100,000	115,000	20.75	71.5	224	too tough	1550 oil 1200
150,000	159,500	15	57.3	319	82.5	1550 oil 1000
180,000	205,500	12	54.6	397	44.5	1550 oil 800
210,000	235,000	10.25	46	452	30.1	1550 oil 600

TENSILE TESTS OF NICKEL CHROME STEEL—TABLE 6.

Analysis—C., .44; Si., .034; Mn., .50; P., .013; S., .013; Cr., .48.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
63,750	107,300	25.0	46	37.2		Annealed
113,000	132,000	17.25	52.5	45.9		1500 oil 1000
154,000	172,500	13.25	49.1	41.8		1500 oil 800
185,000	207,500	12.0	46.3	21.4		1500 oil 600
				14.8		1500 oil 400
				33.3		1900 oil 800

TENSILE TESTS OF CHROME STEEL—TABLE 7.

Analysis—C., .44; Si., .45; Mn., .81; P., .013; S., .015; Cr., .78.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
113,000	129,000	23.0	61.7	250	too tough	1500 oil 1200
162,000	175,000	14.5	52.0	337	62.3	1500 oil 1000
185,500	205,000	12.5	50.0	398	41.1	1500 oil 800
221,000	259,000	8.5	38.3	455	12.1	1500 oil 600
53,500	104,000	22.5	48.0	189	42.4	1400 oil 800
185,000	209,000	11.75	45.9	404	36.0	1700 oil 800
177,500	204,000	9.0	35.0	384	26.4	1900 oil 800
52,000	100,000	22.5	43.3	184	25.1	Annealed.

TENSILE TESTS OF CHROME VANADIUM—TABLE 8.

Analysis—C., .16; Si., .16; Mn., .36; P., .007; S., .019; Cr., .37.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
45,000	76,000	20.0	69.5	145	too tough	1450 oil 600
45,000	76,250	29.4	69.5	145	too tough	1500 oil 600
45,000	78,000	29.5	69.2	160	too tough	1550 oil 600
45,000	81,000	20.5	69.5	168	too tough	1600 oil 600
71,000	92,000	25.5	70.3	178	too tough	1700 oil 600
				58.1		1550 water 600
				82.6		1600 water 600
115,000	148,000	13.5	62.0	292	80.9	1700 water 600

TENSILE TESTS OF CHROME VANADIUM STEEL—TABLE 9.

Analysis—C., .29; Si., .27; Mn., .72; P., .014; S., .010; Cr., .92.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
160,000	198,000	10.5	43.3	326	38.31	1650 oil 0°
135,000	148,000	12.5	59.8	298	85.125	1650 oil 600
113,000	135,000	17.5	64.5	250	too tough	1650 oil 1000
135,000	145,000	12.5	50.0	300	59.75	1750 oil 1000
137,000	148,000	12	58	305	47.175	1850 oil 1000
128,000	147,000	10.5	55	310	37.5	1950 oil 1000

TABLE 12B.

Analysis—Ni., 3.06; S., .010; P., .011; Mn., .70; Si., .18; C., .30; Diameter 1" rod. Distance between grips 16".

Elastic Limit	Maximum Strength	Twist per in.	Remarks
56,000	99,400	138.5	1550° F. oil 1200° F.
61,200	99,300	161.0	1550° F. oil 1200° F.
65,250	115,000	202.3	1550° F. oil 800° F.
66,200	115,500	195.0	1550° F. oil 800° F.
25,480	86,500	100	Annealed
23,000	83,900	100.5	Annealed

TORSION EXPERIMENT—TENSILE TESTS—28 C CHROME NICKEL—TABLE 13A.

Analysis—C., .28; Si., .29; Mn., .34; P., .008; S., .008; Cr., 1.62; Ni., 3.63. Diameter 1" rod. Standard tensile test pieces from middle. Tensile test pieces cut from unstressed portion.									
Elastic Ratio		Max'm Ratio		Red.					
Limit	Tor.	Strength	Tor.	Elong. of					
pr sq. in.	lbs.	pr sq. in.	lbs.	to in 2"	Area	Ten.		Brinell	Remarks
110,000		131,000		21.0	68.0	281-281		1550 oil	1200
108,500	55.0%	130,500	84.2%	20.5	70.0	250-250		1550 oil	1200
162,500		187,500		15.0	58.5	337-384		1550 oil	800
160,500	50.0%	185,000	78.0%	14.0	56.8	370-370		1550 oil	800
105,000		167,750		14.0	33.7	298-298		Annealed	
82,000	27.2%	131,500	78.0%	17.5	61.2	298-250		Annealed	

TORSION TEST—SUMMARY—28 C CHROME NICKEL—TABLE 13B.

Analysis—C., .28; Si., .29; Mn., .34; P., .008; S., .008; Cr., 1.62; Ni., 3.63. Diameter 1" rod. Distance between grips 16".

Elastic Limit	Maximum Strength	Twist per in.	Remarks
59,850	110,400	193.2	1550° F. oil 1200° F.
61,000	109,000	201.2	1550° F. oil 1200° F.
81,300	143,400	82.2	1550° F. oil 800° F.
81,300	146,000	83.3	1550° F. oil 800° F.
25,475	118,500	22.9	Annealed
25,475	117,800	73.4	Annealed
80,000	54.5%	118,500	96 % 17.5 63.5

Carbzd. 1675 24 hrs

TORSION TEST—SUMMARY—30 C 3% PER CENT NICKEL—TABLE 11b.

Analysis—C., .19; Mn., .70; Si., .10; P., .009; S., .019; Ni., 3.48. Diameter 1" rod. Distance between grips 16".

Elastic Limit	Maximum Strength	Twist per in.	Remarks
40,700	116,300	91.2	1550° F. oil 400° F.
40,700	126,500	73.0	1550° F. oil 400° F.
40,700	126,800	81.4	1550° F. oil 300° F.
40,700	126,100	108.7	1550° F. oil 300° F.
30,500	73,900	163.4	Annealed
35,800	75,850	131.9	Annealed
49,500	109,200	20.0	Carburized 1/32—
48,400	113,000	21.7	1500° F. oil 600° F.
			1500° F. oil 600° F.

TORSION EXPERIMENT—TENSILE TESTS—30 C 3% PER CENT NICKEL—TABLE 12A.

Analysis—C., .30; Si., .16; Mn., .70; P., .011; S., .010; Ni., 3.66. Diameter 1" rod. Standard tensile test pieces from middle. Tensile test pieces cut from unstressed portion.

Elastic Ratio	Max'm Ratio	Red. Limit Tor.	Strength Tor.	Elong. of in 2" Area	Ten. Brinell	Remarks
50,500	47.0%	91,750	92.5%	15.0	52.7	176-238 Ann'd brke nr end
87,000		114,000		19.5	66.0	238-266 1550 oil 1200
86,000	68.5%	110,000	80.5%	21.0	67.5	225-250 1550 oil 1200
102,000		132,000		16.5	59.2	281-298 1550 oil 800
103,500	64.4%	132,750	87.0%	18.0	58.2	298-295 1550 oil 800
51,500		93,000		18.5	50.7	170-225 Annealed

TORSION TEST—SUMMARY—30 C 3% PER CENT NICKEL. TENSILE TESTS OF CHROME VANADIUM STEEL—TABLE 10.

Analysis—C., .48; Si., .19; Mn., .85; P., .009; S., .007; Cr., 1.26; V., .18.

Elastic Lim.	Max'm Strgth	Elong. in 2 ins.	Red Area	Brinell No.	Impact	Remarks
150,000	172,000	14.0	53.0	340	79.6	1650 oil 1200
175,000	193,000	12.0	50.0	382	36.9	1650 oil 1000
195,000	218,000	12.0	46.0	420	30.3	1650 oil 900
210,000	240,000	10.0	44.0	460	25.6	1650 oil 800
220,000	261,000	8.0	37.0	470	23.4	1650 oil 600
240,000	290,000	6.0	31.0	410	25.7	1650 oil 400
.....	300,000	.....	.....	485	20.0	1650 oil 200
160,000	185,000	15.0	59.0	360	23.7	1450 oil 800
200,000	235,000	12.0	47.0	448	27.3	1500 oil 800
				27.0		1550 oil 800
205,000	239,000	10.5	43.3	446	27.8	1600 oil 800
210,000	240,000	10.0	44.0	450	27.9	1650 oil 800
212,000	244,000	11.0	46.0	465	27.3	1700 oil 800
211,000	242,000	10.5	44.0	470	26.4	1750 oil 800
211,000	242,000	10.0	41.0	476	20.2	1800 oil 800
211,500	240,000	7.0	36.0	470	6	1900 oil 800

TORSION EXPERIMENT—TENSILE TESTS—20 C 3% NICKEL—TABLE 11a.

Analysis—C., .19; Si., .10; Mn., .70; P., .009; S., .019; Ni., 3.48. Diam. 1" rd.; standard tensile test pieces from middle; tensile test pieces cut from unstressed portion.

Elastic Ratio	Max'm Ratio	Red. Limit Tor.	Strength Tor.	Elong. of in 2" Area	Ten. Brinell	Remarks
83,500		122,000		17	56.7	1550 oil 400
86,500	48 %	128,500	97 %	16.5	47.4	1550 oil 400
93,000		132,250		16.5	49.1	1550 oil 300
89,000	44.8%	125,500	98.0%	17.0	53.5	1550 oil 300
49,000		75,750		23.5	67.0	Annealed

TORSION EXPERIMENT—TENSILE TESTS—40 C C. S. M.**TABLE 14A.**

Analysis—C., .42; Si., .43; Mn., .81; P., .013; Cr., .79; Diameter 1" rod. Standard tensile test pieces from middle. Test pieces cut from unstressed portion.

Elastic Ratio		Max'm Ratio		Red.		Brinell		Remarks
Limit	Ten. lbs.	Ten. lbs.	Ten. lbs.	to	in 2" Area	Ten.	Ten.	
pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	
94,000	120,500	19.0	82.2	255-266	1550 oil 1100			
95,000	70.0%	121,250	91.5%	22.0	82.2	266-238	1550 oil 1100	
127,500	66.1%	150,000		15.0	50.0	337-316	1550 oil 900	
130,000	65.0%	160,750	83.0%	14.5	49.5	298-316	1550 oil 900	
46,000		87,500		30.0	63.2	168-203	Annealed	
45,000	67.5%	81,000	94.5%	21.0	64.0	153-214	Annealed	

TORSION TEST—SUMMARY—40 C C. S. M.—TABLE 14B.

Analysis—C., .42; Si., .43; Mn., .81; P., .013; Cr., .79. Diameter 1". Distance between grips 16".

Elastic Limit		Maximum Strength		Twist per in.		Brinell		Remarks
Limit	Ten. lbs.	Strength	Ten. lbs.	per in.	Ten. lbs.	Ten. lbs.	Ten. lbs.	
66,200	106,500	109.7	1550°	F. oil 1100°	F.			
66,200	112,400	145	1550°	F. oil 1100°	F.			
86,700	131,200	44.4	1550°	F. oil 900°	F.			
81,400	135,800	54	1550°	F. oil 900°	F.			
30,700	80,500	130.5	Annealed					
30,700	78,800	145.5	Annealed					

TORSION EXPERIMENT—TENSILE TESTS—35 C CHROME VANADIUM—TABLE 15A.

Analysis—C., .33; Si., .17; Mn., .72; P., .01; S., .009; Cr., .99; V., .18. Diameter 1" rod. Standard tensile test pieces from middle. Tensile test pieces cut from unstressed portion.

Elastic Ratio		Max'm Ratio		Red.		Brinell		Remarks
Limit	Ten. lbs.	Ten. lbs.	Ten. lbs.	to	in 2" Area	Ten.	Ten.	
pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	
130,000	148,250	18.5	59.2	298-316	1675 oil 1300			
104,000	58.5%	121,250	82 %	20.0	63.5	250-273	1675 oil 1300	
104,000		121,750		18.0	63.7	238-250	1675 oil 1100	
100,000	64.5%	116,750	84.4%	19.0	64.7	250-281	1675 oil 1100	
113,000		141,000		17.5	61.1	298-316	1675 oil 900	
113,000	63.8%	140,000	78.2%	16.0	59.9	298-298	1675 oil 900	
106,000		122,750		20.0	64.0	266-258	1600 oil 1100	
110,000	58.4%	126,750	83.5%	18.5	63.5	266-281	1600 oil 1100	
113,500		140,000		17.0	60.0	266-316	1800 oil 1100	
119,000	57.5%	145,500	86.6%	17.0	57.6	266-289	1800 oil 1100	
56,000		91,500		26.0	67.5	225-185	Annealed	
54,500	72 %	86,750	91 %	24.0	67.7	168-193	Annealed	

TORSION TEST—SUMMARY—35 C CHROME VANADIUM**TABLE 15B.**

Analysis—C., .33; S., .17; Mn., .72; P., .01; S., .009; Cr., .99; V., .18. Diameter 1" rod. Distance between grips 16".

Elastic Limit		Maximum Strength		Twist per in.		Brinell		Remarks
Limit	Ten. lbs.	Strength	Ten. lbs.	per in.	Ten. lbs.	Ten. lbs.	Ten. lbs.	
71,300	118,400	126.8	1675°	F. oil 900°	F.			
68,600	103,300	125.0	1675°	F. oil 1300°	F.			
66,100	97,900	109.7	1675°	F. oil 1100°	F.			
66,100	102,400	109.3	1675°	F. oil 1100°	F.			
71,200	121,600	33.0	1675°	F. oil 1300°	F.			
73,850	120,300	118.0	1675°	F. oil 900°	F.			
61,500	103,500	110.8	1600°	F. oil 1100°	F.			
66,100	106,400	102.2	1600°	F. oil 1100°	F.			
66,500	122,800	98.2	1800°	F. oil 1100°	F.			
66,500	125,800	110.0	1800°	F. oil 1100°	F.			
39,400	84,750	190.6	Annealed					
34,400	77,500	161.6	Annealed					

TORSION EXPERIMENT—TENSILE TESTS—50 C SILICO MANGANESE—TABLE 16A.

Analysis—C., .50; Si., 1.85; Mn., .71; P., .013; S., .007. Diameter 1" rod. Standard tensile test pieces from middle. Test pieces cut from unstressed portion.

Elastic Ratio		Max'm Ratio		Red.		Brinell		Remarks
Limit	Ten. lbs.	Ten. lbs.	Ten. lbs.	to	in 2" Area	Ten.	Ten.	
pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	pr sq. in.	
92,500	131,500	22.0	54.4	308-238	1675 oil 110			
95,000	68.4%	133,000	91.0%	21.5	52.0	266-266	1675 oil 1100	
116,500		144,250		17.0	49.9	298-316	1675 H20 1100	
119,000	40.0%	147,000	87.5%	16.0	47.7	194.5-225	An'd brke nr end	
62,500		95,000		29.5	60.6	308-314	1675 H20 1100	
63,000	58.4%	97,250	80 %	19.0	51.1	180-214	Annealed	

TORSION TEST—SUMMARY—50 C SILICO MANGANESE—TABLE 16B.

Analysis—C., .50; Si., 1.85; Mn., .71; P., .013; S., .007; Diameter 1". Distance between grips 16".

Elastic Limit		Maximum Strength		Twist per in.		Brinell		Remarks
Limit	Ten. lbs.	Strength	Ten. lbs.	per in.	Ten. lbs.	Ten. lbs.	Ten. lbs.	
66,100	120,200	103.2	1675	oil 1100				
61,000	120,000	97.7	1675	oil 1100				
76,900	126,000	102.2	1675	water 1100				
64,050	128,100	121.2	1675	water 1100				
35,600	91,300	116.5	Annealed					
38,200	92,400	113.4	Annealed					

Electric Furnace in Making Special Steel

Installation of Furnace for Producing Steel of Widely Varying Grades—Method of Electrical Control for Any Combination of Series and Parallel Electrode Use.

By CHARLES C. LYNDE.

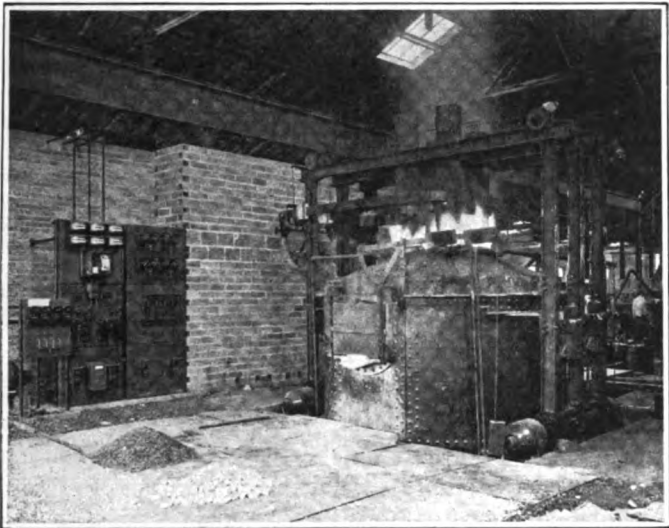
Production of electric steel has been carried on at the Detroit plant of the Railway Steel Spring Company uninterruptedly since July, 1915, in which an electric furnace that is practically new to the United States has been giving excellent results. The furnace is basically a Swedish design, under the name of the Grönwall, and is marketed in Europe as the Electro-Metals furnace, from the name of the sales company engaged in placing it. The American furnace is basically that of the European type, save that it has been changed and adjusted to meet the local conditions here and is known as the Grönwall-Dixon furnace, and is adapted for melting and refining. The furnace at the Railway Steel Spring plant was the first installed in this country, and its progress has been closely watched by other potential furnace users.

The furnace, as appears in the illustrations, is cylindrical, for structural and metallurgical considerations, and is arranged with the usual motor driven tilting mechanism. One of the special features of this furnace is the halved silica roof, made with a supporting steel ring, and so fitted that it may be quickly removed and

another substituted without appreciably interfering with the operation of the furnace. The roof is stated as giving service for seventy-five to ninety heats, depending upon the type of work exacted of the furnace, though at the Spring plant it has been the practice to replace it on the average of every two weeks. Other refractory parts of the furnace are showing surprising life, the cost of refractories being very slight.

Two doors are fitted to the furnace, the front one serving normally for both charging and pouring, through the use of a removable spout. The doors are removable for relining or patching and so located that they do not appreciably weaken the cylindrical strength of the furnace. Counterbalanced electrodes are used, their weight being all carried by a structure of beams spanning the furnace proper, thus relieving the top from all strains set up by the electrodes. Motor control is provided for each electrode, a separate motor drive being fitted for each. The amount of current for each electrode may be set at any one of a number of predetermined amounts by the furnace operator, after which the electric control of the electrode will keep the

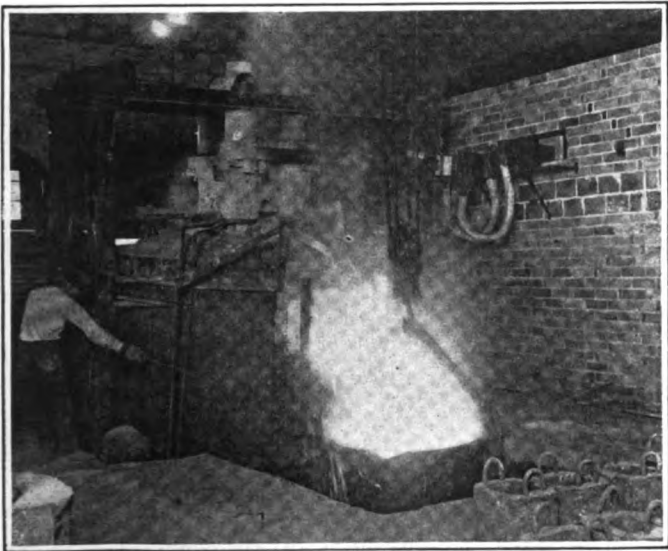
current flow at the figure set, without further supervision. Indicating instruments are attached to each electrode main, located under the immediate observation of the furnace operator. One melter and an asistant can easily watch the operation of a battery of three or



Control Panel for electric furnace.

more furnaces with this type of centralized indicating control.

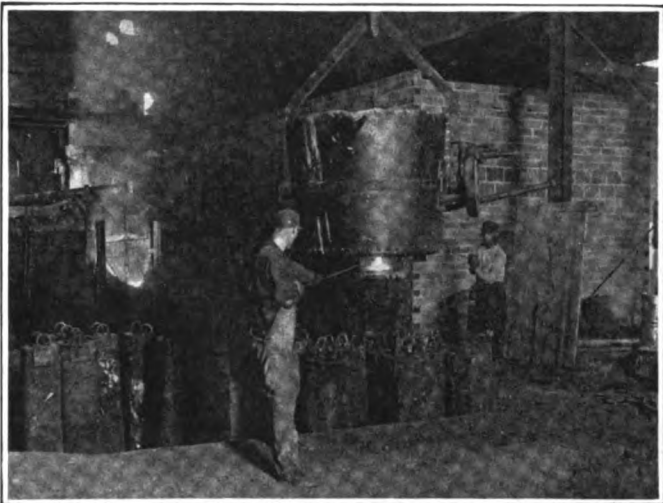
Two-phase current is used in this furnace, with four suspended electrodes and a neutral one fixed in the hearth. And, although operating on two-phase plan,



Tapping furnace into ladle.

three-phase current is used through two banks of transformers, with the interposition of a modified Scott three-phase to two-phase connection. At the Railway Steel Spring plant, where the furnace is a five-ton type, four suspended electrodes are used, and this arrangement is recommended for all furnaces over the size mentioned, while for lighter furnaces two electrodes are found

sufficient. The arcs may be thrown in series through a special switch linkage, in which case the bottom electrode will carry the unbalanced load; while when operating in parallel the bottom electrode—of carbon and protected from the molten metal by being embedded in the lining of the hearth—serves as a common return. It is also possible, through the linkage of switches and leads, to obtain several operating conditions between series and parallel. With this arrangement it is stated that when melting on a cold charge or bottom when the resistance is high, rapidity of operation can be secured with the added economical advantage that large power input through a long arc of high voltage can be



Electric furnace in background—pouring from ladles into ingot molds.

used without a waste of energy by passing large currents through the bottom.

Later this voltage can be reduced when refining, recarburizing, etc., by shortening the arc and thus decreasing decidedly the reflected heat on the walls and roof, which, of course, lowers the cost per ton of metal. Either the parallel or one of the modified connections is used with the short arc, the current passing through the bath to the bottom electrode; thus the proportion used is capable of a wide number of variations. This electrical control is said to give a desirable load, with a transformer efficiency of about 98 per cent. The power factor is given between 90 and 95 per cent.

The Steel Spring furnace has been operated on all types of steel scrap, and has turned out basic heats of a wide variety of steels, as is shown by the following analyses, chosen at random :

Heat Number	C	Mn	S	P	Si	Cr	Ni	Va
164	.32	.65	.017	.027	.18		3.17	
831	.150	.65	.030	.016	1.47	.35	1.00	
798	.082	.43	.037	.013	.052		3.20	
52	.436	.92	.021	.020	3.22	.26		
536	.46	.47	.027	.035	.119	1.08	1.87	
477	.61	.73	.015	.022	.130	.79		.18
889	.320	.47	.022	.022	.117	.86	3.00	
957	.430	.21	.017	.022	.127	2.41	3.91	
969	.021	.026	.027	.0016	Trace			

Each heat is allowed from four to five hours according to information given out by the John A. Crowley

Company, Detroit, agents for the furnace. The average energy consumption is from 550 to 600 kw. hr. per ton. Three hours is the time reported for some favorable heats where the steel made averaged under 0.02 per cent sulphur and phosphorus and the current draft was only 460 kw. hr. per ton.

The cost of producing a ton of liquid alloy steel or steel castings, refined to 0.025 per cent or under of phosphorus and sulphur, based on a year's operation of this 5-ton furnace, is given as follows:

	Liquid Alloy Steel	Steel Castings
Electric energy, 550 kw.-hr., at 8c	\$ 4.40	
	(500 kw.-hr.) \$ 4.00	
Electrodes, 20 l b., at 5½c per lb.....	1.10	1.10
Refractories	0.40	0.40
Alloys	0.61	0.61
Slag mixture:		
00 lb. lime per ton of steel	0.25	0.35
6 lb. fluor spar per ton of steel		
10 lb. of coal per ton of steel		
Scrap and iron	14.00	12.00
Skilled labor	0.70	0.60
Unskilled labor	0.30	0.12
Total	\$21.26	\$19.18

About 5 pound of standard ferromanganese per ton

of steel are found to be necessary to raise any steel from a minimum of 0.30 to 0.40 per cent manganese to the desired content. About 6 pound of 50 per cent ferro-silicon per ton of steel are added to bring the steel to 0.15 per cent silicon. The estimated cost is 43c. for the manganese and 18c for the silicon. Special alloys for special steel are extra.

The cost figures are based on the making of high-grade alloy steels to meet severe specifications, and it is emphasized that in producing steel castings these costs can be decidedly reduced because of no necessity to analyze the metal before tapping.

The John A. Crowley Company is building a new plant of its own, situated in the western section of Detroit. It will have a 10-ton Grönwall-Dixon furnace and all facilities for rolling its billets into desired shapes. Later the present 5-ton furnace will be removed to the new plant. A complete modern plant, capable of expansion, will be the result. It is the belief of the promoters of this furnace that the large electric furnace unit as a successful competitor with the open-hearth is a development to be confidently expected.

Air Drying Methods for Blast Furnaces

Cryogenic and Chemical Means for Drying Blast Considered.
Description of One Type of Process Which Gives Large Volumes
at Relatively Low Production Cost.

By LEON CAMMEN.

The methods of drying air for use in blast furnaces may be divided into two classes: Cryogenic (cold using) and chemical.

The method of drying air by cold may again be divided into two classes, those using dry cold (Gayley, Roberts and Gayley, Haslam, L. Sterne & Company), and the methods resorting to the use of cooling liquids in direct contact with air.

The dry cold methods have been found efficient, but require an expensive installation.

The chemical processes are nearly all based on the affinity of dry calcium chloride for moisture, and vary mainly in the methods of effecting the contact between the air and the salt, cooling of the salt and its regeneration.

In the Fryer process air is passed over broken pieces of calcium chloride which latter is regenerated in special boilers.

In the Cremer process a desiccating chamber is used, in which regeneration of the calcium chloride may be carried on on the spot; on the other hand, the Cremer process does not provide for a very intimate contact between the air and the salt.

Paper contributed to the Proceedings of the Engineers' Society of Western Pennsylvania, by the author.

The Elsner process differs from the two preceding ones mainly through a better mechanical arrangement providing for the movement of the salts, dry and regenerated, in the apparatus.

The various Harbord processes use, instead of plane calcium chloride, inert substances impregnated with hygroscopic salts at very high temperatures.

Finally, in the process of Daubine and Roy air is brought into contact with dry calcium chloride cooled by a flow of water through pipes located in the lower part of the pile of salt. After the salt has absorbed so much moisture that its efficiency as a drying agent begins to be impaired, it is regenerated by gradually raising to a temperature between 175 and 225 deg. Cent.

The great disadvantage of all chemical processes lies in the high cost of running the plant and its large heat consumption (7500 calories per kilogram of water extracted, for regenerating the chlorides from the hydrates, to which must be added the power consumed by the pumps, fans, etc.)

The present process effects the absorption of the moisture from the air not by reducing the temperature of the air to the desired point of saturation, but by bringing the air, under special conditions, in contact

with a proper hygroscopic body. In this particular the process approaches more closely the class of process of drying air by chemical reaction. It differs however, from them in that it uses not dry calcium chloride, but a properly concentrated solution of this or a similar salt maintained at a proper low temperature.

From the process of Bruce Walter, who also uses a brine at low temperature, the present process differs in the following way: In the Walter process the reduction of the moisture in the air is due exclusively to the lowering of the temperature, and hence it is impossible to obtain air containing moisture below the point of saturation for the given temperature. In fact, brine is used by Walter only because it is the cheapest means to use

chloride maintained at a proper low temperature, and is there freed of such moisture as it may contain.

The cold brine moves in countercurrent to the air, and after meeting it proceeds to an evaporator where it is brought back to the initial degree of concentration. It is then sent along a series of cooling coils until it reaches the desired low temperature, and is ready to meet the incoming air again.

On its way from the evaporator to the concentrator the warm brine is first cooled by a stream of water, and then flows in countercurrent to the cold brine going to the evaporator. The advantages of this arrangement, not novel in itself of course, are particularly great with this process.

An essential feature of the present process is the fact that in the evaporator only a concentration of the brine, and not drying of the salt, is carried on. This results in the fact that only comparatively low temperatures have to be used.

As stated above, the whole process is based on the fact that the power of absorption of moisture of calcium chloride brine of high concentration is tremendously increased by its low temperature: 30 per cent brine will absorb water with great avidity at 16 deg. F., but reaches a state of equilibrium at 60 deg. Hence, it will give most of the water absorbed when raised to, say, 100 deg. F., provided the air over the surface of the warm brine is not allowed to reach a state of saturation. Of course, actually a higher temperature would have to be used, as evaporation at 100 deg. would be far too slow. Still, this fact materially affects the heat consumption.

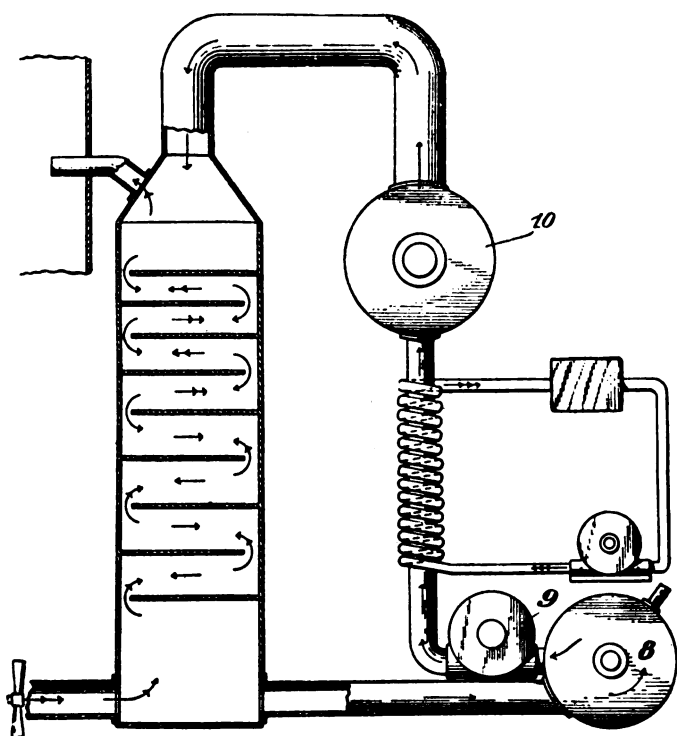


Fig. 1. Blast Furnace Air-Drying System.
Single-headed arrows—Brine. Double-headed arrows—Air
Triple-headed arrows—Cooling water.
No. 8, Evaporator. No. 9, Pump. No. 10, Cooling Plant.

under the circumstances, but apart from this the drying could be just as easily carried on with cold mercury as with cold brine. In the present process the use of brine is absolutely essential. On the other hand, the temperature at which the brine is used, is a matter of secondary importance determined, not by the temperature of air as in the Walter process, but mainly by the degree of concentration of the brine.

The present process is based on the fact that the drying action of a solution of calcium chloride depends on two things, the degree of concentration and the temperature at which the liquid is maintained. Thus, a 30 per cent solution neither gains nor loses water when in contact with air. The same solution at 16 deg. F. takes in moisture with great avidity.

The process involves therefore the use of the following cycle of operations. In the first place air is passed through a highly concentrated solution of calcium

Tentative Institute Program.

For the meeting of the American Iron & Steel Institute to be held in New York City at the Waldorf Astoria Hotel May 25th and 26th, the following tentative programme has been announced, subject to change and addition:

President's address, Elbert H. Gary.

"Recent Installations of Large Turbo Generators," Richard H. Rice, engineer, General Electric Company, West Lynn, Mass.

"The Chemical Reactions of Iron Smelting," Walter Mathesius, superintendent blast furnaces, Illinois Steel Company, South Chicago, Ill.

"The Manufacture of Steel Castings," Robert P. Lamont, president American Steel Foundries, Chicago, Illinois.

"The Relative Merits of Forming Steel by Pressing, Hammering or Rolling," John Lyman Cox, Midvale Steel Company, Philadelphia, Pa.

"Surgical Discoveries of the War and Their Application to Industrial Accidents, Humanitarian and Economic Features," Dr. William O'Neill Sherman, chief surgeon, Carnegie Steel Company, Pittsburgh, Pa.

Making and Buying Sheet and Strip Stock

Cold Rolled Steel as Considered from the Point of View of the Maker and User—Kinds of Special Stock Oftenest Specified. Processes Necessary for Manufacturing Each.

By F. WALTER GUIBERT.

Due to the fact that there is little of record on these two articles, they probably are the most difficult of all the products of a rolling mill for the automobile engineer to specify, not only that the sheet or strip maker will know exactly what is wanted and needed, but that the articles may be purchased at the least expense to the buyer. Therefore, I will try to be as explicit as possible in this paper.

Sheets.

The sheet steels used in the manufacture of automobiles run the gamut of the tempers and finishes produced by a sheet mill, and beginning with the lower finishes we have in their order, light gauge plate, then blue annealed sheets, hot rolled box annealed, one pass cold rolled box annealed, three pass cold rolled box annealed, and then come what are termed the automobile sheets. Inasmuch as this paper treats only of cold rolled sheets, this is necessarily the product of what is termed a merchant sheet mill to distinguish from the product of a jobbing mill. A jobbing mill produces light gauge plate and blue annealed sheets, which latter name is on account of the sheet carrying a heavy blue scale due to annealing in an open furnace and cooling in the air. The product of the merchant sheet mill is annealed by means of placing the sheets in large boxes, either cast iron, cast steel or wrought steel, tightly sealed, and kept in a soaking heat for several days. Contrary to the general understanding, light gauge sheets are rolled transversely from what is termed a sheet bar, whereas the blue annealed sheets of a jobbing mill are the continued reduction in the same direction from the slab in the one heating. Sheet bars come in lengths 30 ft. to 40 ft. long, are always 8-in. wide, and the thickness is the controlling factor, and varies according to the length of the finished sheet desired. These sheet bars are rolled from a bloom on either a universal mill or a sheet bar mill, and are delivered to the sheet mill cold, where they are cut into small lengths to correspond with the width of the sheet ordered, and are rolled transversely across the 8-in. face. A sheet ordered No. 20 ga. by 30-in. wide by 120-in. long, would require, therefore, a sheet bar 30-in. long to correspond with the sheet width, and must be of sufficient thickness that when rolled out to 120-in. in length, it will be just No. 20 ga. Therefore, the sheet bar required would be $\frac{5}{8}$ -in.

Paper read by the author before the Steel Treating Research Club, Detroit, Mich.

thick. These bars are then heated in the pair furnaces to a temperature where the scale starts to raise; are drawn in pairs from the furnace and passed singly through the hot rolls the 8-in. way of the bar. Five passes of reduction are usually given the bars and they are then paired and reheated for further reduction. For the lighter gauges these pairs are doubled upon themselves, making four sheets in a pack and are rolled to gauge. The necessity of hot rolling these sheets doubled or double-doubled is due to the impracticability of rolling light gauge sheets singly through the hot rolls, owing to the spring of the rolls, the rapidity of the cooling of the sheet and the small tonnage produced. The hot rolls are turned up slightly concave when cold, to make allowance for the expansion caused by the heat during rolling.

After the sheets are hot rolled to gauge they are trimmed and given one pass through the cold rolls and annealed. These sheets form the basis of the product of a merchant sheet mill and are called one pass cold rolled box annealed sheets. The other names under which they are known are O. P. C. R. & A., black sheets, black iron, sheet steel, box annealed sheets and sheet iron. The base gauge for computing differentials is always No. 28. The base sizes in No. 28 ga. are between 24-in. and 32-in. wide, inclusive, and 60-in. to 132-in. in length, and no extras apply on any intermediate sizes. One pass sheets, when sold as such, may be either Bessemer or open hearth steel, and the allowable variations in gauge and weight is that adopted by act of U. S. Congress, March 3, 1893, which is as follows:

No. 17 Ga. and lighter	2½ per cent in gauge
No. 18 Ga. and heavier	5 per cent in gauge

The allowable variation in width is $\frac{1}{4}$ -in. and in length 1-in. The differentials and extras for sizes, gauges, finishes, quantities and qualities are usually standard with all mills, and lists are easily obtainable. The three pass cold rolled box annealed sheets are the same as the O. P. C. R. & A., with the addition of two extra passes through the cold rolls, which gives them a slightly better surface.

Automobile Sheets.

There are very few mills in this country which have been able to successfully produce automobile sheets on a commercially profitable basis, due to the exactions of the automobile manufacturer, and even these few always produce among their primes, large

quantities of seconds and wasters, so that it has become necessary to insist that the purchaser of automobile sheets absorb a portion of these seconds up to 15 per cent of the quantity of primes, making a fair reduction in price for the seconds.

Sheets for automobiles are divided into three classifications, each of which has its further classifications. The first is body stock; the second hood, splash guard, flat fender, apron and door stock; the third, crown fender, cowl and radiator casing stock. The further subdivisions of each of these classifications consists in tempers and analyses.

Automobile sheets are manufactured much in the same manner as the one pass sheet with, however, many added operations, and each mill has its own method of arriving at the results. The usual method calls for a particular analysis of steel and the sheet bars are pickled before hot rolling, and the product is given other picklings and annealings, together with the necessary cold rollings to produce the various finishes and tempers required. Extreme care is necessary at all times to avoid the many defects which arise in the manufacture of high surfaced sheets such as chatter marks, cold roll marks, corner marks, pits, ripples, buckles, furnace scale, scratches, etc. Cold rolling steel increases the elastic limit and ultimate strength and decreases the ductility. It is necessary, therefore, after cold rolling sheets to anneal them. Otherwise, continued cold rolling will harden them until they become flowered and cracked, so that the number of passes or amount of reduction without annealing is limited. The temper is obtained by cold rolling and a properly annealed sheet being dead soft is hardened or stiffened by means of cold rolling, hammering or drawing.

Body Steel

Body steel is divided into the following classifications: Bright finish and dull or velvet finish and these are divided again into standard stamping or drawing quality, deep drawing quality and extra deep drawing quality. The bright finish is a high glossy surface intended for japanning or enameling. The velvet or dull finish is intended for hand coating and the surface is more or less open to hold the painting operations, such as priming, rough stuffing, and enameling that requires no baking. In these divisions the deep drawing quality is necessary for jobs on which shallow drawing or forming is necessary. Back and side panels are usually ordered in this quality. The extra deep drawing quality, however, is a special analysis and treated sheet produced for difficult and severe drawing operations—such as a wheel house, seat backs, etc. The seconds arising should be usable by putty glazing.

Hood, Splash Guard, Flat Fender, Apron and Door Stock.

This carries a higher finish than the standard

body stock, due to the fact that it is to be japanned or enameled. The primes should be suitable for a two-coat japan finish and the seconds a three-coat finish. This sheet is closer surfaced than the body stock, and is not expected to stand any particular bending or drawing, and should be ordered only for comparatively flat work. Deep drawing and extra deep drawing qualities should be ordered for jobs requiring stamping, rolling, forming or drawing.

Crown Fender, Cowl and Radiator Casing Stock.

This carries the high surface, also suitable for two coat and the seconds three coat japan finishes—at the same time permits of drawing without opening the surface. If the job is an exceedingly difficult draw, this should be ordered in the deep drawing or extra deep drawing quality from the point of economy in production.

This last classification is very apt to show after the draw what are termed drawing or stretcher strains, which are streaks quite visible and consist of a series of depressions or worm marks due to the inequality of the plastic condition of the surface and the interior of the sheet. This is due to the cold rolling and subsequent annealing.

I have been allowed a patent on a process of manufacturing cold rolled sheet metal, such as steel or brass, which will eliminate these strains in drawing any dead soft cold rolled sheet.

After the sheets for automobiles have been finished and annealed satisfactorily, they are passed through a series of small rolls called roller levellers, for the purpose of eliminating whatever buckle may remain in a sheet. However, if an absolutely flat sheet is required, these should be ordered stretcher or patent levelled, which process consists of fastening both ends in a drawing bed and by means of hydraulic pressure the sheets are stretched until they are absolutely flat. It is usually not necessary to order stretcher levelled sheets where a die drawing operation is used, as the draw usually absorbs the slight buckles that might remain after roller levelling, but where a flat highly finished surface is necessary, stretcher levelling is recommended.

It is most economical to have all highly finished sheets oiled. This costs but little extra and assists in prevention of rust during transportation, storing, handling and manufacture of the parts. Condensation of the atmosphere in a freight car is bound to occur, and few cars have roofs which are rain or snow proof, and most storing spaces for the sheets are damp or not of the same temperature as the steel when being stored, which also causes condensation. Perspiration and hand marks as well as scratching in handling are largely avoided when the sheet are properly oiled, and it is best to carry this oil on the sheet through manufacture until the part is ready for enameling or priming, when the oil may be readily removed by gasoline. A

scratch requires a lot of work to undo, and the labor cure is much more expensive than the oil prevention.

If it is necessary to have a sheet square on all four corners they must be ordered resquared. Otherwise the usual variation of 1-in. in length and ¼-in. width must be allowed.

Unless highly finished sheets are ordered in car-load lots they should be crated, as they will be absolutely ruined in transportation and neither the shipper nor carrier will guarantee against damage.

Sheets should be specified under the division they belong, and it is usually best to state to the mill just what the sheets are to be used for, and whether it is a painted or enameled or nickel plated job. Always order, if possible, in the base sizes in order to eliminate the size extras. As most automobile sheets are No. 19, 20, 21 and 22 ga., the corresponding base widths are between 24-in. and 36-in. inclusive, and the lengths from 60-in. to 132-in. inclusive. Fractional sizes within these limits may be ordered without extra, but narrower or wider, shorter or longer sizes carry extras. No. 17 and No. 18 ga. may be ordered as narrow as 20-in. up to 36-in. wide without extra and from 48-in. to 144-in. in length without extra. Always try to confine the maximum width to 36-in. and maximum length to 120-in. if possible, and preferably between 24-in. and 30-in. in width and from 60-in. to 96-in. in length, as the best surfaces can be produced in these sizes. Never hesitate to pay the deep drawing or extra deep drawing differentials for difficult jobs, as the loss in manufacture and production usually amounts to more than the higher quality of sheet would have cost.

Always order sheets by U. S. Standard Gauge and not by thousandths of an inch.

Each mill has its pet analysis for the different steels in making sheets, but the tempers are always obtained by the cold rolling and the amount of screw in the cold rolls. However, the method of reduction and treatment in operation are as essential as the analysis in producing satisfactory results. The standard analysis for auto parts is substantially as follows:

Carbon	.08	.15
Manganese	.35	.50
Phosphorus	.04	and under
Sulphur	.04	and under

For extra deep drawing purposes the steel should not exceed the following:

Carbon	.12
Manganese	.40
Phosphorus	.03
Sulphur	.04

The physicals are as follows:

	Scl'scope	Elastic Limit Pounds	Ultimate Strength Pounds	Elong. in 2" pr ct	Red. of Area pr ct
Hood and flat fender stock..	31	77,000	86,000	8	42
Body stock	29	74,000	81,000	10	46
Pickled and annealed one pass stock	27	55,000	74,000	19	55
One pass cold rolled pickled and annealed	26	40,000	68,000	44	62
Hot rolled annealed	24	31,200	59,000	29	67

Undoubtedly all these sheets for automobiles will be made of alloy steel at some future time—not only for the purpose of reducing weight but for the increased strength desired in certain parts. Frames and stamped connection rods are already under discussion, and who knows but what some enterprising engineer will develop a sheet steel fender which will not crumple up under the slightest blow or a body which will stand a good thump without showing a dent and ruining the whole appearance of the car.

Cold Rolled Strip Steel.

Differing radically from sheet steel, the manufacture of cold rolled strip is a continued rolling of the product of a hoop or band mill, is reduced cold and is never cross rolled. The billets being reduced in the hoop or band mill to hot rolled strips, are delivered usually in coils to the cold roller. Here they are picked to remove all scale, and by successive passes through the cold rolls reduced to the gauge desired. Sufficient thickness of steel, however, must be used so that the cold rolls polish and fill the more or less open surfaces of the hot rolled band or hoop during reduction, and the finished strip should have a surface suitable for nickel plating without further polishing. It is usually necessary to anneal between the reductions in cold rollings and contrary to the usual opinion, the temper is obtained, not by annealing, but by cold rolling after annealing, and it is here where the art of the strip maker reaches its pinnacle.

There are five different tempers produced and the sclerescope is as follows:

Dead soft—Griffin Mfg. Co., "E" temper	18-21
Soft—Griffin Mfg. Co., "D" temper	20-22
Medium soft—Griffin Mfg. Co., "C" temper	24-26
Bright rolled or half hard—Griffin Mfg. Co., "B" temper....	32-35
Full hard—Griffin Mfg. Co., "A" temper	38-40
All of these tempers are obtained by cold rolling.	

When thoroughly annealed, the strip is dead soft, and can be used for the most difficult of deep drawings. It is very much better than sheet steel for drawing purposes, due to the fact that it has been reduced cold, and has not been cross rolled. The soft temper is for ordinary bends and easy draws, and in which a certain amount of stiffness is desired in the finished article. The medium soft is intended for a stamping which will stand a right angle bend across the grain, fairly well with the grain, and is quite springy. The hard or full hard, as it is usually termed, is the strip cold rolled to size and unannealed, and is very hard and suitable only for discs, washers and other flat work.

Always specify cold rolled strip steel in thousandths of an inch or by Birmingham or Stubbs gauge and never by U. S. Standard, Washburn and Moen, or Brown and Sharpe. As strip steel may be furnished either sheared or mill edge, it is best, where stripper dies are used, to the sheared edges for accuracy, inasmuch as there is a certain bulging on the side of the strip. However, the sheared edge may carry a slight burr from the slitting. When ordering steel for shims,

which may be rolled as thin as one thousandth of an inch, always specify shim stock, as this should be given some cold rolling after annealing.

The extras and differentials for cold rolled strip steel are very intricate, and it is usually best to call in the strip salesman when prices are to be figured, inasmuch as the base price is on coils, hard temper, 1½-in. and wider, by .100 and thicker, in 50 tons or more quantity. You can realize the variations from the above base are numerous. There are extras for thickness; extras for temper; extras for straightening and cutting; extras for special widths; extras for boxing, and extras for quantity; and these lists are easily obtainable, and the engineer should consult them before specifying.

For instance, No. 18 ga. Birmingham or Stubbs is .049 thick, which carries an extra for thickness of 20 cents. If the engineer were to order this in .050, the extras for thickness would be but 5 cents, so that the difference of one thousandth of an inch is sometimes more than saved by the lower differential.

Strip steel is always oiled, and should always be boxed or wrapped to prevent damage in shipment, rust, etc.

Analysis.

The standard analysis for soft steel is used in strip,

but special analysis is often necessary, particularly as regards the carbon content for such parts as brake bands, friction discs, etc. The allowable variation in gauge and width and length is as follows:

One to two thousandths over or under in thickness and on slit edge stock, 1/64-in. wider or narrower and mill or round edge, 1/16-in. over.

The physical properties are as follows.

Temper	Yield point, pounds	Maximum Load lbs.	Yield point, lb. per sq. in.	Tensile strength, lb. per sq. in.	Elongation in. 8 in.	Elongation, per cent.	Reduction of area per cent.	Fracture
A .. .1223	10500	10900	85860	89120	.12	1.5		
A .. .1223	10400	10900	85040	89120	.14	4.0	46.3	Silky
B .. .0925	5900	6300	63790	68110	.10	5.0	46.3	Silky
B .. .0942	5950	6250	63160	66350	.38	19.0	47.2	Silky
C .. .1001	5800	6100	53160	55910	.52	6.5	58.3	Silky
C .. .1076	5650	5860	52500	54460	.35	17.5	70.2	Silky
D .. .1196	3950	5800	33030	48500	1.32	16.5	67.9	Silky
D .. .1194	3900	5650	32660	47320	.79	39.5	72.7	Silky
E .. .1223	4050	5700	33110	46600	1.04	52.0	73.0	Silky
E .. .1237	3850	5750	31120	46480	2.46	30.7	73.7	Silky
				Elongation in 2"	1.06	53.0		
				Elongation in 2"	2.64	33.0		
				Elongation in 2"	1.02	51.0		
				Elongation in 2"	2.80	35.0		
				Elongation in 2"	1.12	56.0	67.3	Silky

Discussing Sulphur in Low Carbon Steel

J. S. Unger, Pittsburgh, Pa., Prof. Hayward has presented the results of an investigation along a line to which I have devoted considerable time and attention, and I am particularly pleased to note that his results are in accord with my own and further tend to prove the fact that the old established prejudice against sulphur is based more on belief than actual facts.

I have felt for years that too much stress was placed on the harmful influence of certain elements in steel such as sulphur, phosphorus, copper, etc., but it has only been within recent years that efforts have been made to establish the truth. Practically all the investigations made to date have proven that these elements within reasonable limits are harmless and, in fact, that for certain purposes the addition of these elements is beneficial.

In referring to copper, J. E. Stead, vice-president of the British Iron and Steel Institute, said at their last meeting: "Even to-day one comes across steel specifications in which copper is barred, which can only be regarded as an indication of ignorance, if not stupidity, of those who prescribe the composition of steel, for it has been long ago proved that copper in steel, instead

of being an evil, is quite harmless, and sometimes distinctly beneficial."

Sulphur owes its evil name to the early days of the manufacture of steel. Chemical analyses were crude, and failure due to either poor raw materials or metallurgical treatment were many. Sulphur being a comparatively easy element to determine with reasonable accuracy, particular attention was called to the amount of sulphur, and the failure was attributed to it, without giving any consideration to other causes. A prejudice against sulphur was thus formed, which has existed to this day. As a result, the permissible sulphur content in steel is so low in some cases that it is questionable if the excessive purification necessary to produce such results is not detrimental to the steel.

It has been my experience in the working of steel, that occasionally a high-sulphur steel would roll or work much better than a lower-sulphur steel, yet the steels would be apparently the same in composition, excepting the sulphur. At other times the reverse would be true, and the lower-sulphur steel would roll better than the high-sulphur steel. If a certain amount of sulphur produces a particular effect, to be consistent it should always produce the same effect.

My investigation of the influence of sulphur in steel covered tests of considerable quantities of several kinds

Discussion of paper by Carle R. Hayward on the Effect of Carbon on Low Sulphur Steel, presented before the American Institute of Mining Engineers.

of steel in various sizes ranging from small roofing nails to 8-in. channels and railway axles, with sulphur contents of from 0.025 to 0.254 per cent.

The products tested were rivets, machine- and hand-made chains, sheets, wire, nails, tubes, pipe, drop forgings, plates, axles, rails and wire cable. Owing to the variety of products investigated, it was sometimes necessary to use steel a little softer or harder than that ordinarily used for the same purpose. This, however, had no influence on the comparative results.

In the fabrication of these products, the usual works practice was followed in the production of the finished article, no preference being given in the treatment of steel of one sulphur content over that of another. The material was subjected to the tests regularly prescribed for steel products of the varieties mentioned and, in addition, special tests were made on most of the products.

It was not my object to study the state in which the sulphur existed in steel, or its microstructure. What I wanted to learn was what effect different amounts of sulphur had on the working of the steel and its effects on the properties of the finished article. This is what concerns the user of the steel.

A paper read before the Society of Automobile Engineers and published in their Proceedings for 1916 and in the *Iron Age*, January 13, 1916, gives the results of a great many of these tests, particularly those of interest to the automobile industry. Another paper presented before the American Boiler Manufacturers' Association and published in their Proceedings for 1916 and in *The Blast Furnace and Steel Plant*, July, 1916, describes an extensive series of tests on the influence of sulphur in rivet steel.

I will not review these results here, but will briefly refer to some of the tests which were not covered in these papers; such as tubes, plates, rails and wire products.

Referring first to the tests on tubes, a series of fifty 2-in. boiler tubes were made of each sulphur content, and all met the regulation hydraulic pressure test without failure. The practice on the tube of 0.050 and 0.090 per cent sulphur was better than the practice on the tubes containing 0.030 per cent sulphur. A series of 4-in. seamless tubes were also made and subjected to different tests. The tubes of 0.068 sulphur as a whole gave better results than the 0.032 per cent sulphur tubes. In the higher-sulphur steels there was a slight falling off in tensile strength, but an increase in ductility as shown by the elongation.

The investigation of plates consisted of an extensive series of longitudinal and transverse tensile, torsion and bend tests, welding and hot and cold flanging tests. The results of these tests were practically the same for plates of all sulphur contents.

Steel of 0.51 per cent carbon with varying sulphur contents was rolled into 100-lb. rails. Tensile and drop tests were made. There was a slight decrease in the

tensile strength in the high-sulphur rails, but an increase in ductility as shown by the elongation in both the tensile and drop tests. Rails of each sulphur content were then put into actual service in a railroad track, and although lower in carbon than steel ordinarily used for rails, which reduced the life of the rails, all of them, regardless of the sulphur content, showed about the same amount of wear.

In the investigation of wire products, one of the studies made was the influence of sulphur in the manufacture of roofing nails with a very large, thin head. The upsetting of the head is a particularly severe operation, yet the steel of the highest-sulphur content made as perfect a head as the lower-sulphur steels.

Another study was the electrical welding of wire. When welding the wires for continuous drawing or in the manufacture of fencing, where the wires are welded at right angles to each other, it was found that steels of sulphur contents could be perfectly welded.

In making the regulation twist and bend test of galvanized wire, the wires all met the requirements of this test, and the coating adhered perfectly, regardless of sulphur content.

The tests of wire cable showed that cables containing up to 0.10 per cent sulphur gave practically the same results in the tensile, twist and life tests.

Attention has been called by the investigators to the fibrous condition of high-sulphur steels. This fact was particularly noticeable in our study of case-hardening. After the steels had been case-hardened and quenched, all showed the same depth of case and hardness. When fractured, the low-sulphur steels would snap off square and show a crystalline fracture, while the higher-sulphur steels, instead of snapping off square, had to be bent backward and forward before they would break, and the fracture would be irregular and have a fibrous appearance.

The result of this investigation confirmed my belief that steel could contain a great deal more sulphur than that usually permitted and still be of good quality. The work of Wallberg, Arnold, Stead, Cooper, Hayward and other investigators has done much to strengthen this belief. There is still a large field for investigation and a much larger work in distributing the knowledge thus gained to all those interested. This seems to be the only way by which any erroneous beliefs can be replaced by actual facts, which later find a practical application.

• George F. Comstock, Niagara Falls, N. Y., The results of tests given in Prof. Hayward's paper are interesting, and are worthy of serious attention by those who advocate an appreciable increase in the permissible limits of sulphur content in steel. It does not seem, however, that Prof. Hayward in his conclusions has rendered an entirely impartial verdict. The beginning of the paper would indicate that he started out with the intention of proving if possible that sulphur up to 0.1

or 0.15 per cent does no harm to steel, and the tensile tests were extremely encouraging to such a conclusion. It should be noted, however, that the high-sulphur steels were no better on the whole in the tensile tests than the low-sulphur steels.

The impact tests, on the other hand, do show a marked difference in favor of the low-sulphur steels, but Prof. Hayward is apparently unwilling to admit in his conclusions that any particular importance attaches to this fact. The excuse is given that the shock test is new and its value not thoroughly appreciated by all engineers. This, I suppose, is a matter of opinion, but it surely would seem that a glance through the published records of technical societies interested in metals or their testing, both in this country and Europe, should be sufficient to show that the shock test is not new but is well known and extensively used. Looking at the matter from the viewpoint of the designing engineer, it might be asked how metals usually fail in service, whether by slow, gradually increasing tension, or from small repeated stresses which cause fatigue or from sudden shocks? It seems obvious that failure from pure slow tension practically never occurs in service, and that fracture from shock is far more common although probably not so common as failure from fatigue. When looked at in this light it is hard to see why Prof. Hayward's shock test results should not be given serious attention in judging of the practical value of high-sulphur steels.

The actual results of the work described in this paper may be summarized as follows: Tensile tests showed on the whole no difference between high-sulphur and low-sulphur steels; impact tests showed a distinct difference in favor of low-sulphur steels; microstructure not discussed. In view of this summary, where nothing is shown in favor of the high-sulphur steels, but one point of decided superiority is brought out for the low-sulphur steels, is there any logical escape from the conclusion that steel low in sulphur is better and safer to use than steel with high sulphur?

The failure of the tensile tests to show a difference between these classes of steel is very similar to its results on steels with varying amounts of phosphorus, or on steels heat-treated differently. It has been shown by very eminent authorities that steel high in phosphorus may give good tensile strength and elongation, and still show great brittleness in shock tests. This is a case directly in line with Prof. Hayward's results with sulphur, and if high-phosphorus steels are considered unsafe to use in spite of fairly good tensile results, then Prof. Hayward's paper can only be regarded as showing that high-sulphur steels are equally unsafe.

I notice that Prof. Hayward does not discuss the microstructures of these samples, although photomicrographs were made and are reproduced in the paper. I would like to ask what conclusions are to be drawn

from them? It always seems unfortunate to me that photomicrographs should be considered as proving anything in themselves in cases like this, for of course no two photomicrographs even of the same sample would be exactly alike. The true use of a photomicrograph is, I believe, in illustrating points that would be less clear without the actual views, and I would like to ask whether Prof. Hayward considers that these photomicrographs show the structures of high-sulphur and low-sulphur steels to be alike, or, if not, what differences are shown?

If photomicrographs had been made before the samples were etched, there is no doubt that much greater differences would have been shown in the cleanness of the metal. The excessive amount of non-metallic manganese sulphide in the high-sulphur steel could be easily seen in an unetched sample, and would illustrate well the reason why such steel is easy to machine, and also why it is brittle and unfit for severe service. Sulphide inclusions are as harmful as any other non-metallic impurities in steel, and more so than some because they tend to segregate. Unless we disagree entirely with the eminent authorities who maintain that non-metallic inclusions are harmful in steel, we cannot logically admit that high-sulphur steel is all right.

It is unfortunate that Prof. Hayward did not continue the investigation to include alternating stress tests, even if new stock would have been required. Surely he does not consider his results of no general value and inapplicable to any but the identical steels on which he worked, and it is not clear why the results of fatigue tests on high-sulphur and low-sulphur steels should have any "uncertainty in their interpretation" merely because the stock was different from that used in the impact and tensile tests. It is to be hoped that such an investigation will soon be made, in order to show, more clearly even than Prof. Hayward's present results show it, why high-sulphur steel is unsafe to use for severe service.

M. H. Medwedeff, Springfield, Mass., I recollect when Dr. Ungers' paper on the "Effect of Sulphur in Steel" appeared, I intended to offer a criticism more with the hope of having some more competent authority challenge the rather revolutionary statements contained therein. It was, however, never published, as I hoped to secure substantiating figures in defense of the current specifications for sulphur limits.

While connected with a steel works producing merchant open hearth bars, splitting ingots in the process of rolling were repeatedly found to be caused by the high sulphur in the steel, the other constituents being normal. The ingots at the same time appear to have a fibrous appearance. This may perhaps be ascribed to the rolling out of the sulphides into filaments. Sulphur exists in steel as MnS , or perhaps both as FeS and MnS , particularly when the manganese content is low. The melting points of these sulphides are considerably below the melting points of hypoeutectoid steel. Now if

the steel is high in sulphur, it contains a considerable amount of MnS or MnS plus FeS; it is reasonable to suppose that as these impurities are of lower melting point, they would be thrown out to the grain boundary of the metal on cooling. Granting that high sulphur may even favor an increase in the tensile strength and elongation, the question rises in one's mind, will such steel stand transverse strains or shocks? Prof. Hay-

ward answers that question himself in his Charpy tests figures. From the above considerations of the discontinuity in the structure of such steels, one may well expect it.

One cannot help but wish that Dr. Unger would give us the secret of how to weld high-sulphur steel; it is the general experience that such steels are stringy and unweldable.

EDITORIAL

A Time for Conservative Buying.

The warnings which have gone out to be conservative in buying, and urging against the purchase of large stocks as a guard against possible shortage, are seemingly required by the attitude of many. Either an attempt to stock full of possible supplies, or a sudden elimination of all buying, marks the hysterical attitude assumed by some on the beginning of a realization of the possible extent and duration of war's demands upon the American principle.

We can learn much of economy through the need for the resources of the country, without in the least interfering with or curtailing normal business. But when the so-called economy is stretched to the point where it calls for the shutting down on normal purchasing and the elimination of all save mere food and drink then others begin to suffer through the pressure thus brought to bear upon their legitimate businesses. Production in almost all manufactures will continue, at as high or higher a rate than previous to the declaration of war, and the market for these commodities will be there, if normal life is maintained in the communities throughout the land.

Taxation, the means relied upon by the government for the securing of the revenue to finance the war, can not succeed if the industries and other money-making channels of the country are closed by a dearth of markets—while wages themselves will be shut off through the forced closing of plants who can no longer dispose of their output. Thus, a sudden and hysterical shutting down on all buying would tie the hands of the government in equipping and maintaining its army, navy and supply depots, and would in turn greatly straiten the conditions of all citizens not directly securing returns in the form of wages for munition making.

Does the tax assessor repose supinely in his office while he waits for you to come around, declare your property value and pay your tax? If he did,

how long would our government be able to exist with purely voluntary tax-paying? If universal taxation for all capable of being citizens, then why not at least selective universal military service for those able-bodied men?

Notice how the steel mills are breaking tonnage records every few days? Just getting in trim so they can turn out government steel as fast as ordered when the need begins.

Strange how patriotic (verbally) a man with a fifty-inch waistband can be—after he has been assured that he is too corpulent to be of possible service at the front.

The Teutonic spy system must be lame to let ships get away from Europe with both French and English emissaries to this country without a submarine even getting a look at either vessel.

True patriotism does not necessarily mean shouldering a gun and marching to the front: for every man in the field we must have at least three workers at home, to keep the one fighting man provided with rations, munitions and other supplies, and the men who do their part toward the production of steel, farm products and other needed articles need be no whit less patriotic than those who give up good jobs at home to wear the uniform and represent the country at the front.

That scrap dealer who bought an old rolling mill some four years ago at a bankruptcy sale, and then found he could not break the equipment into pieces small enough to move and sell advantageously now sees the value of keeping even an apparently useless article rather than let it go at a loss—since he sold the mill to a company that was short on equipment for a little over twice what he bought it in as scrap—without having to turn a hand. Fifty per cent a year on the money he invested wasn't bad, considering.

PRODUCTION TOPICS

Need of Wire Rope Lubrication.

Wire rope is not so simple a thing as its name would imply. As the superintendent of a large wire rope company recently remarked, it is a marvelous machine, and deserves careful consideration. Far from being a bar of inert steel it is a thing always in motion, and in that motion lies its strength. Heavy strains must be met and wear must be equally distributed.

This constant motion means internal friction, a condition which calls for intelligent lubrication. This is a vital matter, as the life of a rope can be greatly prolonged by an understanding of its needs. Much depends upon the initial lubrication, that is, the lubricant which is used to lay up the hemp core around which the strands of the rope are wound. This lubricant should not only retard the effects of friction, but should also act as preserver of the rope and prevent internal destruction due to corrosion caused by contaminated water penetrating to and soaking the core. This chemical action eats away the wires and decreases the tensile strength of the rope. Very often a rope, which appears on the surface to be in perfect condition will fail, and an examination of the interior will disclose wires worn to a needle-like point from lack of internal lubrication and corrosion. Sudden and unexpected breakage is, of course, very dangerous, not to mention expensive.

When a rope is properly lubricated from the inside, less lubrication is necessary from the outside. That the result may be uniform and thorough one lubricant should be used throughout. Sometimes a good external lubricant will not penetrate because of an unsuitable material used internally.

One engineering department investigated the wearing or bearing surface on one hundred feet of wire rope one inch in diameter, which they found to be about 334 square feet. They then made a careful measurement of all of the bearing surface of a 35,000 horsepower reversing engine (one of the largest in the world), and found that there was 319 square feet, actually less than that in the 100 feet of one-inch rope. And yet the wire rope often receives very little attention in the way of lubrication. It is remarkable how long the rope will last when it receives so little attention. Think how much more durable it can be made by the use of a proper lubricant.

Device for Detecting Gas.

Around the blast furnace, equally as in the mine, it is necessary for there to be present some means of detecting dangerous amounts of gas. As C. M. Means points out in "Coal Age," the portable electric miner's lamp whose use is constantly increasing, will not detect the presence of gas, and it is the present practice to use the ordinary flame safety lamp for that purpose. The device under consideration is intended to be used in testing for gas in connection with electric lamps. It consists essentially of two glowers connected in series and placed in a vertical position side by side. These glowers are inclosed with glass and gauze, the glass being for observation purposes and the gauze to allow free circulation of air or gas and still prevent the communication of flame to the outside. The device is not at all likely to ignite gas even if the glass is broken, as the temperature of the glowers cannot be raised to the ignition point of a mixture that can be ignited. This indicates the possibility of making a perfect device that will not ignite methane under any circumstances. It can be placed close to the roof where

gas is most likely to be found, requires no adjustment, and should be equally reliable under all conditions of air.

The presence of gas is determined by comparing the relative brilliancy of the two glowers. In case gas is encountered one of the glowers brightens and the other dims. Exact percentage of gas cannot be ascertained, but can be approximated with a little practice. The principle employed is the use of one glower that will give catalytic action when in the presence of gas and another arranged in the same plane which will not. The glower possessing catalytic properties heated to a proper temperature by some external means will increase in temperature when brought into contact with methane. The glower which does not possess this property is raised to the same initial temperature, but dims when brought into contact with gas, due to the increased resistance of the other glower. So long as the two are in air, they remain at the same temperature and glow alike. Both glowers are made of the same material, but they have undergone a treatment that renders one highly catalytic and the other non-catalytic. By allowing the glowers to be energized for a period of time in mixtures containing high percentages of gas, they may be volatilized. By high percentages is meant 20 per cent methane or more. However, if properly operated there is no occasion for trouble even at these high percentages, since if the temperature is high, the limit of explosibility has passed.

Frame Vibration Responsible for Commutation Troubles.

There are so many well-known possible causes of unsatisfactory commutation that when a commutation trouble occurs with a machine of admittedly good design a trouble seeker is likely to direct his attention to eliminating the most common causes before looking for the more uncommon ones. In one particular instance the generator of a motor generator set, that consisted of a continuous current generator driven by an induction motor mounted on a rather long base, commutated rather badly. The sparking was not sufficiently bad to prevent operating the set, but so long as it continued the commutator could never take a polish, says the "Electrical World."

The operator had checked the speed, voltage, load, polarities, air-gap, field drops, brush sets, brush tensions, brush alignments, brush shift, and also the switchboard instruments, and everything appeared to be perfectly regular. The commutator mica appeared to be flush with the bars, as it is sometimes difficult to tell with certainty whether or not mica is a little high, it was decided to slightly undercut it as an experiment. At this time a turbine construction ban happened along (turbine men are usually very keen for any condition that is likely to produce vibrations), who noticed that oil was breathing out between the bearing cap and pedestal of the middle bearing. This struck him at once as a case of faulty alignment, with the possibilities and causes of which he was thoroughly familiar.

Two iron wedges were made and driven under the centre of the base on opposite sides of the machine. A relief was immediately noticeable, and the vibration that before had been evident only to the most skilful observer was missed at once. The sound emitted by the machine, especially at the brushes, became entirely different, and all sparking ceased. Investigation disclosed that the base of the machine as

originally set was resting on its four corners, so far as the distributing of the weight on the foundation was concerned, and the long span of the base had sagged.

Powdered coal in storage will ignite spontaneously more rapidly than before pulverization. When such powdered fuel contains 0.75 per cent of moisture and 1 per cent of sulphur, it will invariably fire within six days. If the moisture be increased to over 1 percent and the sulphur to 4 or 5 per cent, spontaneous combustion may occur within 24 hours. Probably the temperature at which powdered coal is delivered to the storage bin and the sulphur content of the coal influence the rate of spontaneous combustion more markedly than does the percentage of moisture.

Temperature Measurements in Bessemer and Open Hearth Practice.

J. W. Richards, I think my affections are still rather with the radiation pyrometer than the optical pyrometer, for practical use, and I wish that Prof. Burgess would use the two together, under the same conditions, using the optical as his standard, if he prefers. Then, assuming the optical emissivity which he feels is correct for the optical pyrometer, he could calculate the thermal emissivity for use with the radiation pyrometer. If we could thus get reliable values for the thermal emissivity, we could then use the radiation pyrometer, and would avoid the use of the standard lamp, which has to be frequently calibrated for us in the optical pyrometer.

It is very advisable to distinguish carefully between the terms optical emissivity and thermal emissivity. There is considerable confusion caused by the bare statement that molten iron has an emissivity of so much, meaning by that its optical emissivity, for a light wave of a certain length, whereas what we want in the radiation pyrometer is its total thermal emissivity. I think it would be better to always use the terms optical emissivity and thermal emissivity. I should prefer to go on using the radiation pyrometer where possible, for it does not need a standard of comparison, or a standard light, but needs only the information as to what is the total thermal emissivity of the material being examined.

G. K. Burgess.—Regarding the use of the optical or radiation pyrometer, I purposely avoided the discussion of their relative merits for this purpose. I am perfectly willing that Prof. Richards should use the radiation pyrometer if he wants to get up as close to the hot metal stream as he has to do, to use it. The main difficulty in the use of the radiation pyrometer, as at present constructed, is the danger of not getting sufficient operature when sighting on a small stream and the optical angle is such that you have to put the instrument within a few inches, almost, of the stream. That is a rather serious objection for convenient use. I have taken observations within 10 ft. of the stream from an open hearth furnace, but I do not care to do it as a matter of practice; whereas, with the optical pyrometer, you can be 50 ft. away. I took some observations with the two together only the day before yesterday, and my preference has not been changed by that experience.

R. C. Drinker.—A brief survey of the interesting paper by Mr. Burgess indicates that any discussion I might offer would be of little value, since my work of late years has been in the direction of a measuring apparatus so simple, and yet fairly accurate, that it may be placed in the hands of an operator just able to read figures—a condition so frequently found among steel melters.

Although my methods are crude, in comparison to the able work of Mr. Burgess, yet my contention "that melting

temperatures are quite as critical as those of heat treatment," makes it immaterial whether those determinations are accurate temperature measurements, so long as they are comparatively accurate, i.e., enable one to duplicate tomorrow, a satisfactory temperature of to-day, and thus in time establish valuable data.

Standardization.

At the April regular monthly meeting of the Pittsburgh Section of the Association of Iron and Steel Electrical Engineers, held at the Fort Pitt hotel, Pittsburgh, Pa., Saturday, April 21, 1917, papers on standardization were presented by members of the standardization committee.

W. T. Snyder, chairman of the standardization committee, said in part:—"The need of standardization as it applies to design and application of apparatus and equipment in the industries is apparent to all members of this organization who give thought to this matter. The lack of effort toward standardization, or uniformity is evidenced by the fact that it is necessary to adapt the design of apparatus to the particular make of motor that will be used for driving the same, and the impracticability of interchanging without more or less modification expense, motors made by different manufacturers having the same operating characteristics of a given machine. The standardization committee have a plan outlined which they hope to have presented at the next annual convention which, if adopted, will afford a continuous working program for future standardization committee and avoid the waste effort in new committees deciding upon a plan of action and the delay and lost time incident to getting started. The plan roughly is that the standardization committee composed of a chairman and a certain number of members, each member being chairman of a sub-committee of two or three, each sub-committee following the standardization of a certain division or class of apparatus and equipment."

F. B. Crosby—"Standardization of data and material is desirable just so fast as sufficient practical experience is obtained to warrant the adoption of so-called standards. Standards are much more readily arrived at in connection with physical constance and data as to strength of materials than in connection with apparatus. Standardization of apparatus tends to cheapen the cost per unit production but it also inevitably tends to handicap development. The manufacturer cannot afford to be continuously changing designs nor is the purchaser willing to accept them, consequently it is often a long time before improvements clearly recognized as desirable by both parties actually appear in the commercial article. The work of the standardization committee particularly in its initial stages must of necessity be slow if a conservative yet comprehensive foundation is to be laid, upon which our successors in years to come can build up a structure sufficiently flexible to meet the demands of progress."

H. F. Stratton—"The logical way to start standardization is to standardize a common language, by means of which all interested persons can refer to control apparatus without ambiguity. This means standardizing definitions, terms, symbols, wiring diagrams, etc. The electrical manufacturing companies are already endeavoring to employ the new terms and definitions by embodying them in letters and quotations and by changing printed matter as rapidly as possible. People engaged in standardization should constantly be on the alert to make sure that they do not in any way stifle developments in new designs or hold back the progress of the electrical industry."

H. D. James—"The standardization work of the electrical engineer is international in its scope and is very well organized. At present we are working toward a centralized organization in this country. The Association of Iron and Steel

Electrical Engineers should endeavor to standardize their performance requirements for electrical apparatus and the interchangeability of the same. The standardization work of other associations should be used as far as it is suitable for the iron and steel industry."

T. E. Barnum—"In considering control standardization we find two general divisions:—one the design on the control apparatus which is the business of the manufacturer; the other the application of that apparatus, which is the business of the operating engineer. Application must precede standardization and as it is practicable to standardize only so far as these standards will be adopted by all the operating companies. The following factors in control application should be taken into consideration as a basis for making standards for the operating engineer: 1, disconnecting means

wanted; 2, overload protection wanted; 3, service, classification, or duty; 4, safety requirements; 5, power supply; 6, system of inspection and maintenance. It can easily be seen that a satisfactory set of standards for mill controllers can be attained only by the concerted action of the operating engineers and their coöperation with the manufacturer."

F. D. Egan, president of the association, spoke at length upon the advisability of the motor manufacturers endeavoring to make the various types of mill motors agree with respect to mechanical proportions. His remarks precipitated considerable valuable discussion.

Among others who took part in the meeting were B. R. Shover, F. P. Townsend, E. Friedlaender, James Farrington, Brent Wiley, Otto Schaumberg, Walter Kennedy, L. F. Galbreath, C. A. Menk, and Paul Caldwell.

INDUSTRIAL SAFETY

SERVICE RETIREMENT PLAN OF THE COLORADO FUEL AND IRON COMPANY.

The board of directors have adopted the following service retirement plan for employees, in appreciation of their long and faithful service:

The administration of the service retirement plan shall be in charge of a service retirement board (hereinafter designated the board), consisting of five officials of the company, appointed by the president and approved by the board of directors. The board shall elect a chairman and a secretary from among its membership. A majority of the board shall constitute a quorum for all purposes.

All employees and officials, except the president, who have given their entire time to the service of this company, including its subsidiaries, are eligible for service retirement payments under the following conditions:

First: Compulsory retirement—All men who have reached the age of 65 years, and women 55 years, and who have been 20 years or longer in the service, shall be retired, unless, in individual cases, in the discretion of the retirement board and the board of directors, some later date be fixed for such retirement.

Second: Retirement at request of employee, or in discretion of board—Any man who has reached the age of 60 years, or any woman 50 years, who has been 30 years or longer in the service, may be retired, either at his or her request, with the approval of the board and of the president, or without the request of the employee, in the discretion of the board and with the approval of the president.

Third: Retirement in discretion of board—(a) Any employee who has been 15 years or longer in the service and who, by physical examination, is shown to be permanently totally incapacitated for any service, may, in the discretion of the board and with the approval of the president, be granted a special allowance.

(b) Any employee whose retirement on account of advancing years is, in the judgment of the board, advisable, and who has been at least 20 years in the service, may, in the discretion of the board and with the approval of the president, be retired and granted a regular or special allowance.

The monthly payments for regular allowances which the board may authorize under this plan shall be 30 per cent of the average pay per month of service during the 10 years next preceding retirement; but no regular allowance shall be less than \$20 per month.

Illustration: A retired employee whose pay, during the

10 years next preceding his retirement, has averaged \$80 per month, will receive 30 per cent of \$80, or \$24 per month.

The amount and duration of each special allowance shall be determined by the board.

The term of service shall be reckoned from the date of beginning either with this company or with any one of the various companies and properties that now compose it. Credit shall be given for the time the employee is actually on the pay roll and in active service.

Section 1.—Payments shall be made through the regular disbursing office at the close of each month, and unless otherwise provided shall terminate with the death of the retired employee.

Section 2.—In the discretion of the board these payments may be continued to widows and orphans for a limited period.

Section 3.—In order that employees retired under this plan may continue the personal enjoyment of the benefits granted them, no assignment of amounts authorized will be permitted or recognized under any circumstances. As these allowances are purely voluntary, they shall not be liable, before payment, to claims of creditors or to any attachment or execution for debts of the beneficiaries.

Section 1.—No one retired under this plan shall be barred from engaging in any business not prejudicial to the interests of this company, or of any subsidiary company, but he cannot re-enter the service.

Section 2.—Allowances may be withheld, suspended or terminated by the board in cases of misconduct, violation of law or of these rules, or for other causes sufficient, in the judgment of the board, to warrant such action, or, in the discretion of the board, may be paid to some other member of the family.

Section 3.—This service retirement plan is a purely voluntary provision for the benefit of employees retired after long and faithful service and constitutes no contract and confers no legal rights upon any employee.

Section 4.—The service retirement plan does not give to any employee any right to be retained in the service in addition to that guaranteed in the industrial representation plan, nor does it deprive any employee of any right guaranteed to him by the plan.

DANGER FROM FURNACE GAS.

"Asphyxiation from Blast Furnace Gas" is the title of Technical Paper 106, Bureau of Mines, Department of the Interior, written by Frederick H. Willcox.

This report is issued by the Bureau of Mines in pursuance

of its endeavors to increase safety and efficiency in metallurgical industries. It discusses the nature and causes of poisoning from blast furnace gas, itemizes the places where gas may be expected to be encountered, suggests safeguards and points out the precautions to be taken in working about gaseous places.

Blast furnace gas is peculiar in that it is very poisonous and under certain conditions, as when it has been cleaned, is without color or odor by which it may be detected. Gas is practically always present about the top and bottom of the furnaces, frequently in such small proportions that it is not evident to the physical senses, but at the same time in sufficient volume to cause asphyxiation if breathed steadily for 20 or 30 minutes. Proportions sufficient to cause asphyxiation or gassing also occur with more or less frequency all along the route of the gas, at the stoves and boilers when they are taken off for cleaning or repairs, inside of gas mains, downcomers, and other parts of the gas-main system, at sand or goggle valves, and during repairs to the charging equip-

ment and stock line. The increasing application of furnace gas-driven blowers and generators has introduced additional equipment such as tower washers, fans, and other cleaning devices that also must be entered from time to time for cleaning and repairs. At all the above places there is always the possibility that gas may be present where the crews have to work, either from leakage, insufficient ventilation, or from emission of gas retained in the brickwork, flue dust, or deposits in the apparatus. Though poisoning by blast furnace gas usually results in nothing more serious than illness and severe headache, it may cause unconsciousness and even death, and realization of the dangers and a strict observance of every precaution is essential in undertaking any work in an atmosphere contaminated by furnace gas, or in sending men into confined places, from which it would be difficult to escape, in proximity to material emitting gas or difficult to ventilate. Copies of this publication may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.

NEWS OF THE PLANTS

The Huntington, Ind., Steel Foundry Company, A. L. White president, is installing an electric furnace for the manufacture of electric furnace steel castings, and has retained Barton R. Shover, consulting engineer, Pittsburgh, in connection with the installation thereof.

An interesting feature of the emergency hospital of the American Steel & Wire Company, at Fairfield, Ala., is that the office of the safety inspector adjoins that of the surgeon in charge. When an accident case is brought in, the safety inspector makes an investigation of the cause of the injury at the same time that the surgeon is preparing to take care of it.

LARGE ORDER FOR TATA COMPANY.

The Tata Iron & Steel Company, Sakchi, India, has awarded contracts for all the equipment and construction on its new steel plant to the Pennsylvania Engineering Company, New Castle, Pa. The contract, totalling almost \$1,000,000, calls for one 1,300-ton mixer, two 25-ton converters, and one 200-ton open hearth furnace. All this equipment is as large or larger than any other units heretofore erected, both the mixer and the open hearth furnace equalling for capacity any in the world. The contracting company will also furnish all the auxiliary equipment, which will be erected in the home plant, and then knocked down and shipped to the Indian site for erection. This plant is scheduled for active production about July, 1918.

A Washington office of the Society of Automobile Engineers will be opened in Munsey building in connection with the Council of National Defense as soon as arrangements can be made. This action decided upon by the Council of the Society was brought about by the closer coöperation of the Society with the various Government departments which work is increasing every day.

The Society is well pleased with the results of its coöperation with the Quartermaster's Department as shown by the specifications of the 1½ and 3-ton military trucks given out this week. The Truck Standards Division of the Standards Committee has assisted the Quartermaster's staff in revising these specifications. Other work, and a great deal of it, remains to be done. It is possible the Society will

assist in aviation standardization work, and also in the training of mechanics for aviators as well as in training and supplying mechanics for many other parts of war service.

The Council of National Defense has expressed a willingness for closer assistance by the S. A. E. and the Washington office in this light becomes a necessity. General Manager Coker F. Clarkson or his assistant Herbert Chase, will probably represent the Society almost continuously in the Washington office.

At the meeting of the Board of Directors of the American Iron and Steel Institute on March 28, 1917, Alva C. Dinkey, President of the Midvale Steel Company, was elected a Director of the Institute to succeed E. C. Felton, resigned.

There were elected to the waiting list, Frederick W. Cohen, works manager, Goldschmidt Thermit Company, 120 Broadway, New York City.

W. F. Ripperger, assistant to vice president, Goldschmidt Detinning Company, 120 Broadway, New York City.

Henry Gulick, president, Gulick Henderson Company, 21 Park Row, New York City.

Samuel S. Buckley, president, Onondaga Steel Company, Inc., Syracuse, N. Y.

Cecil E. Bertie, assistant to the president, Virginia Iron, Coal and Coke Company, Roanoke, Virginia.

David D. Hull, vice president, Virginia Iron, Coal and Coke Company, Roanoke, Virginia.

John D. Newton, president, Virginia Iron, Coal and Coke Company, Roanoke, Virginia.

Joseph F. Savage, general manager of sales, The American Tube & Stamping Company, Bridgeport, Conn.

Joseph Becker, superintendent of operation, H. Koppers Company, Pittsburgh, Pa.

Horace C. Porter, chemical engineer, H. Koppers Company, Pittsburgh, Pa.

John W. Kiser, Jr., president, Phoenix Horse Shoe Company, 52 Vanderbilt Ave., New York City.

The Butler Iron Company, recently incorporated for \$2,000,000, has an ore reserve of approximately 10,000 acres of land, on which it plans to put up charcoal and wood distillation plant for producing sufficient charcoal for the oper-

ation of a 50-ton charcoal furnace—which will also be built in the near future. Work has already been begun on the preparation of the ore land for efficient mining operations, and the erection of the wood and charcoal distillery will be begun as soon as the most advantageous site has been selected. The plants are to adjoin Poplar Bluff, Missouri.

The Allis-Chalmers Company report for the year ended December 31, 1916, shows a profit of \$2,902,312, an increase of \$2,171,217 over the previous year. The net profit equals \$19.18 per share on the preferred stock, as compared with \$6.53 in 1915. Sales amounted to 19,440,509.

The Inland Steel Company, Chicago, has bought from the Indianola Coal Company, Pittsburgh, 2,000 acres of coal land about 14 miles northeast of Pittsburgh. The ultimate expenditure by the Inland Steel Company will be about \$2,000,000. Plans call for the building of a railroad spur, the sinking of a shaft and the establishment of a town. The coal mined will be used to supply the company's 130 coke ovens, none of the product being put on the market. The coal property will be operated under the old name. It was partly for the purpose of acquiring this property that the Inland Steel Company recently obtained a Delaware charter.

Papers for the Iron and Steel Institute, to be read at London on May 3 and 4, are as follows:

"The Penetration of the Hardening Effect in Chromium and Copper Steels," by L. Grenet, Firminy, France; "Steel Ingot Defects," by J. N. Kilby, Sheffield; "Cementation by Gas Under Pressure," by F. C. Langenberg of Harvard University, Cambridge, Mass.; "Origin and Development of the Railway Rail," by G. P. Raidabaugh, Sparrows Point, Md.; "Case Hardening of Iron by Boron," by N. Tschischewsky, Tomsk, Russia; "Determination of the Line S.E. in the Iron-Carbon Diagram by Etching Sections at High Temperatures in Vacuo," by N. Tschischewsky and N. Schulgin, Tomsk, Russia, and "Influence of Surface Tension on the Properties of Metals, Especially of Iron and Steel," by F. C. Thompson, Sheffield.

The Sharon Steel Hoop Company, Sharon, Pa., makes the following announcement:

The Sharon Steel Hoop Company having purchased the capital stock of the Youngstown Iron & Steel Company, the commercial operations of the two companies will on and after April 1, 1917, be conducted in the name of the Sharon Steel Hoop Company. All remittances and correspondence intended for either the Sharon Steel Hoop Company or the Youngstown Iron & Steel Company should be addressed to the general office at Sharon, Pa. No communications in connection with the business should be addressed to individuals, all mail being addressed to the company.

The six metric myths is the subject of a bulletin, No. 1, issued by the American Institute of Weights and Measures, 20 Vesey street, New York. These myths, which are elaborated upon, are enumerated and exposed as follows:

1.—The system is in universal use except in the United States, the British Empire and Russia, and frequently Russia is placed in the metric column.

2.—The adoption of the system is easy and the transition period short.

3.—There exists a confusion in our weights and measures and the system should be adopted in order to get rid of it.

4.—The system leads to an important saving of time in calculations.

5.—The system leads to an important saving of time in primary education.

6.—The adoption of the system is important in the interest of foreign trade.

New publications of the Department of the Interior, Bureau of Mines, are:

Bulletin 122.—The principles and practice of sampling metallic metallurgical materials, with special reference to the sampling of copper bullion, by Edward Keller. 1916. 102 pp., 13 pls., 31 figs.

Bulletin 128.—Refining and utilization of Georgia kaolins, by Ira E. Sproat. 1916. 59 pp., 5 pls., 11 figs.

Technical Paper 137.—Combustion in the fuel bed of hand-fired furnaces, by Henry Kreisinger, F. K. Ovitz, and C. E. Augustine. 1916. 76 pp., 2 pls., 21 figs.

Technical Paper 138.—Suggested safety rules for installing and using electrical equipment in bituminous coal mines, by H. H. Clark and C. M. Means. 1916. 29 pp.

Technical Paper 164.—Accidents at metallurgical works in the United States during the calendar year 1915, compiled by A. H. Fay. 1916. 20 pp.

Miners' Circular 23.—Elementary first-aid for the miner, by W. A. Lynott and D. Harrington. 1916. 23 pp., 19 figs.

Note.—Only a limited supply of these publications is available for free distribution, and applicants are asked to cooperate in insuring an equitable distribution by selecting publications that are of especial interest. Request for all papers can not be granted. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

Because of war conditions, the summer meeting of the Society of Automatic Engineers, scheduled to be held the last week in June at Ottawa Beach, Lake Michigan, was called off by the council of the society at a meeting held a few days ago in Chicago. An extensive canvass of many connected closely with the activities of the society showed a general feeling that few of the members could afford the time to spend four days on the East shore of Lake Michigan or at any other place. Each day finds the engineers more and more engrossed in war activities, and correspondingly fewer of the members with spare time for such a meeting.

Instead of four days at Ottawa Beach it was voted to spend one day on the summer meeting and hold it in Washington, D. C., on Monday, June 25. Washington was selected because many government departments are closely associated with the work of the society.

With one day for a summer meeting, instead of three of four as has been the custom since the start of the society, the broad program of former years will not be attempted.

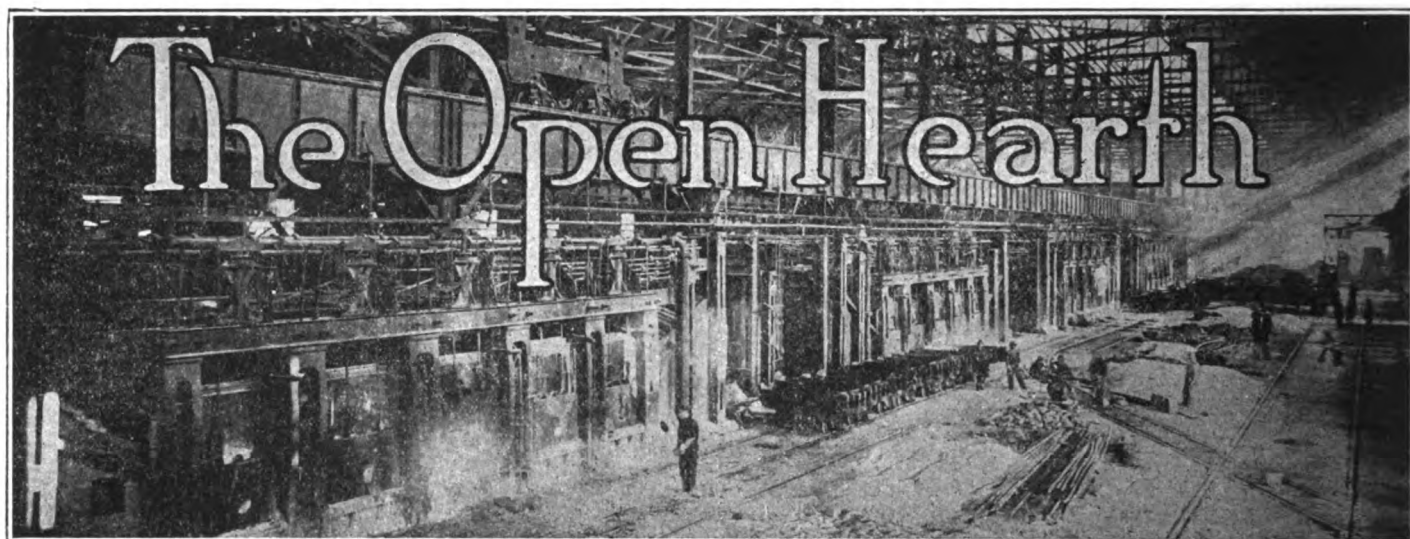
Although the summer meeting in the sense it has been understood in the past has been called off the activities of the society have not been reduced as such announcement might tend to convey. Instead of the large meeting there will be several smaller and more specific ones.

The Ingersoll-Rand Company, 11 Broadway, New York, has recently issued two new catalogs as follows:

Form 3311, 20 pages, 6x9, covering Imperial Type X Duplex Steam Driven Compressors suitable for general industrial application of compressed air. Catalog gives tables of sizes and capacities and is thoroughly illustrated to show the machine in detail.

Form 8507, 40 pages, 6x9, covers Little David Pneumatic Drills. An endless number of various types and models are shown with recommendations as to the particular character of work for which they are adapted. Each tool is illustrated and the several tables give the sizes and capacity of each tool.

Copies of above bulletins free on request to nearest branch office.



Norman L. Baker, formerly mechanical engineer with the By-Products Coke Corporation, Chicago, Ill., has accepted a position as works manager for the American Steel Foundries Company, East St. Louis, Ill.

✓ ✓

Edwin M. Brown has resigned his superintendency of the Columbia plant of the A. M. Byers Company, to become assistant manager for Edward T. Edwards.

✓ ✓

T. E. Buck, formerly in the drafting department of the Donora Steel Company, Donora, Pa., has resigned to become associated with the United Engineering & Foundry Company, at Springfield, Ill.

✓ ✓

Waddill Catchings has been made president of the Sloss-Sheffield Steel & Iron Company, Birmingham, Ala., succeeding James N. Wallace.

✓ ✓

Ambrose N. Diehl, since November 1915 assistant general superintendent of the Duquesne Works of the Carnegie Steel Company, Duquesne, Pa., has been promoted to be assistant to the vice-president of the Carnegie Steel Company, with his headquarters in the general offices of the Carnegie Steel Company, in the Carnegie Building, Pittsburgh. He has been with the Duquesne plants of the Carnegie Company since 1899, beginning



his steel mill work in the laboratory there.

✓ ✓

P. Chrystie has been added to the list of vice presidents of the Taylor-Wharton Iron & Steel Company, High Bridge, N. J., becoming the third.

✓ ✓

V. A. Cronk, who has been connected with the Phillips Sheet & Tin Plate Company, Weirton, W. Va., has resigned to accept a location with the Wickwire Steel Company, Buffalo, N. Y.

✓ ✓

James W. Deetrick, general manager of plants for the Republic Iron & Steel Company, with headquarters at Youngstown, Ohio, has been made a director and second vice president. He began his connection with the steel industry as chemist for Hannah furnace of the Mahoning Iron Company, Youngstown, later amalgamated in the Republic

company. He was later made general superintendent of blast furnaces in the Youngstown district for the company, and before being made general manager of plants was in charge of the Brown-Bonnell mills and all stacks.

✓ ✓

C. E. Crowthers, superintendent of Haselton furnaces of the Republic Iron & Steel Company, Haselton, Ohio, has been made superintendent of Northern furnaces of the company, with headquarters at Youngstown, Ohio, succeeding J. N. Reese, promoted.

✓ ✓

W. H. Eshelman becomes superintendent of the plate mill department of the Youngstown Sheet & Tube Company, East Youngstown, Ohio. He was formerly plate mill roller for the Republic Iron & Steel Company, at the Youngstown plant.

✓ ✓

J. Edmund Good has been placed in charge of a new department for the handling of bolts, nuts, bar iron, etc., of the American Steel Export Company, Woolworth building, New York City. He was formerly with the American Iron & Steel Manufacturing Company, Lebanon, Pa.

✓ ✓

Leon O. Hart, electrical engineer for the Driver Harris Wire Company, Harrison, N. J., has been made assistant treasurer of the company.

✓ ✓

A. W. Haven becomes blast furnace superintendent at the Haselton (Ohio) furnaces of the Republic Iron & Steel Company, vice C. E. Crowthers, promoted.

✓ ✓

John C. Hoar, master mechanic for the Chateaugay Ore & Iron Company, Lyon Mountain, N. Y., has resigned to become general foreman of repair departments for the American Locomotive Company, Schenectady, N. Y.

✓ ✓

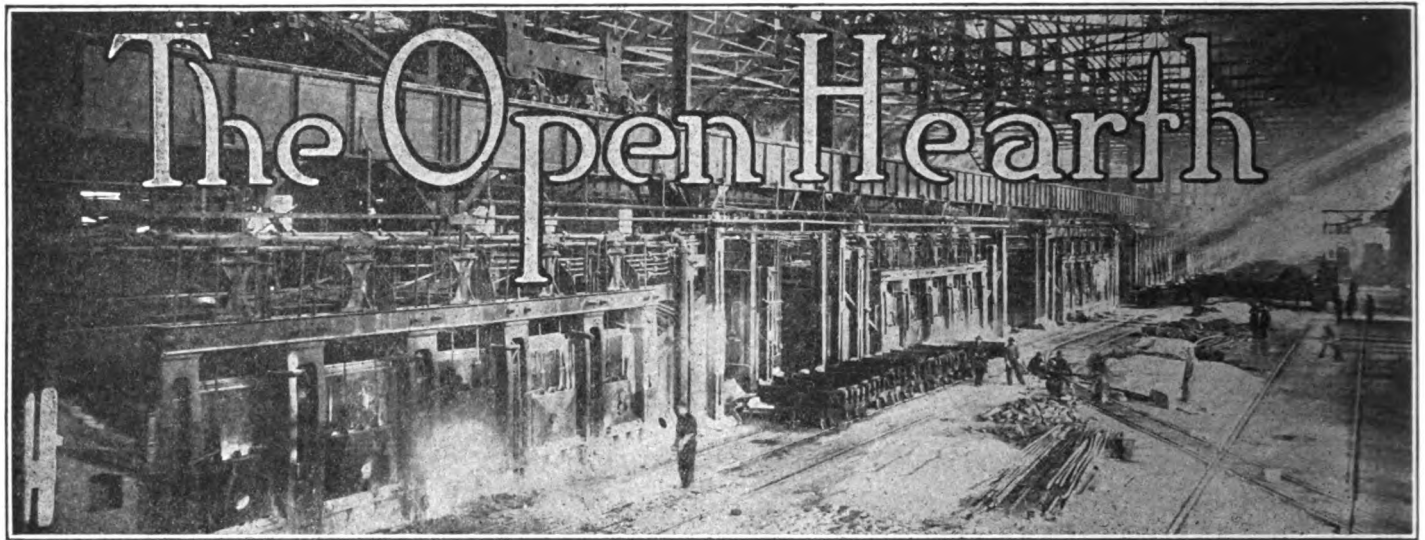
Charles Holzworth, former superintendent of Ella Furnace, West Middlesex, Pa., has been put in charge of both of the West Middlesex stacks owned by E. W. Mudge & Company, the Claire furnace being added to the Ella.

✓ ✓

Noble Jones has been made general superintendent of the Sharon plants of the Sharon Steel Hoop Company, with headquarters at Sharon, Pa.

✓ ✓

Carl W. Pierce has resigned as open hearth superintendent of the Central Steel Company, Massillon, Ohio, to



become superintendent of open hearth for the Cromwell Steel Company, Lorain, Ohio.

✓ ✓

John N. Reese, superintendent of Northern blast furnaces for the Republic Iron & Steel Company, with head offices at Youngstown, Ohio, has been made assistant general manager, in charge of mining operations.

✓ ✓

C. C. Rice, who has been at the Dover, Ohio, plant of the American Sheet & Tin Plate Company for the past twenty years, now is superintendent of the Deforest Sheet & Tin Plate Company, Niles, Ohio.

✓ ✓

H. H. Roberts is now chief engineer of the LaBelle Iron Works, Steubenville, Ohio, vice William Forsstrom, resigned.

✓ ✓



Arthur W. McAuly, who has been for some time connected with the Inter-Ocean plant of the Railway Steel Spring Company, Chicago Heights, Ill., in the position of assistant chief electrician, recently resigned this work to become affiliated with the Edgewater Steel Company, Oakmont, Pa., where he is employed in the capacity of assistant chief electrician.

✓ ✓

Edward Salts has become superintendent of the plant of the Lewis Foundry & Machine Company, Groveton, Pa. He was formerly connected with the Jeffrey Manufacturing Company, Columbus, Ohio.

✓ ✓

G. Walter Sanborn, formerly purchasing agent for the William Tod Company, Youngstown, Ohio, has been made assistant purchasing agent for the United Engineering & Foundry Company, Pittsburgh, the latter company having absorbed the former.

✓ ✓

W. F. Schaphorst has opened an engineering advertising service office in the Woolworth building, New York City.

✓ ✓

J. M. Schlendorf, director of sales for the Central Steel Company, Massillon, Ohio, for fourteen years was with the United States Steel Corporation, connected with the American Sheet & Tin Plate Company in various capacities.

✓ ✓

Barton R. Shover, consulting engineer on steam and elec-

trical power applications to the iron and steel industry, on May 1 moved his offices from 704 Diamond Bank building, Pittsburgh, to Rooms 424-5-6, Oliver building, where enlarged quarters have been secured.

✓ ✓

J. D. Vail, former manager of the Salt Lake City office of the H. W. Johns-Manville Company, has been made manager of the building materials department at that company's Chicago branch.

✓ ✓

Charles S. Vought has been appointed assistant manager of sales for the American Steel Export Company, New York City. He was formerly a manager in the order department of the Cambria Steel Company, Johnstown, Pa.

✓ ✓

A. G. Whitehouse, formerly rolling mill draftsman for the Morgan Engineering Company, Alliance, Ohio, and before that at the Ohio Works of the Carnegie Steel Company, Youngstown, Ohio, has accepted a position in the engineering department of the LaBelle Iron Works, Steubenville, Ohio.

✓ ✓

Howard Wood, Jr., assistant secretary of the J. Wood & Brothers Company, Conshohocken, Pa., has been made manager of the same plant for the Alan Wood Company, also of Conshohocken.

✓ ✓

George H. Woodroffe has become mechanical and metallurgical engineer for the Parkesburg Iron Company, Parkesburg, Pa. He was formerly superintendent of the forge department of the Philadelphia Steel & Forge Company, Philadelphia, Pa.

✓ ✓

A. E. Woolsey has resigned from the Anniston Steel Company, Anniston, Ala., and is now located at 30 Church street, New York City.

✓ ✓

S. G. Worton, open hearth superintendent at the Duquesne Works, Carnegie Steel Company, Duquesne, Pa., has been made assistant general superintendent of the Duquesne plant, vice A. N. Diehl, promoted.

At the meeting of the directors of the American Iron and Steel Institute held on Wednesday, April 25, Eugene G. Grace, president of the of the Bethlehem Steel Company, South Bethlehem, Pennsylvania, was elected a director of the institute to succeed Frank S. Witherbee, deceased.

Some Pointers on By-Product Coke Oven Operations

Carrying further the salient operations in the recovery of benzole from gas, as begun in the paper by F. W. Sperr, Jr., in this department in the April number of this publication. After the benzol, toluol, xylol and solvent naphtha have distilled off, a certain amount of wash oil containing naphthalene remains in the still tank. The presence of wash oil in the light oil is due not only to mechanical trapping of the heavy oil during the distillation, but also to the actual distillation of some of its original constituents by agency of the direct steam used. The products recovered from 1000 gal. of light oil vary according to the kind of coal, the regulation of the ovens and the method of operation of the light oil plant. In one plant that may be taken as fairly typical of a well-operated system the yields average about as follows:

From 1000 gal. crude light oil.
680 gal. crude benzol.
140 gal. crude toluol.
50 gal. crude xylol.
55 gal. solvent-naphtha.
75 gal. wash oil residue with naphthalene.

The wash oil remaining in the still is drained into the cooling pan where it is cooled in the air to crystallize out the naphthalene. The wash oil is drained away from the latter into tank and then is returned to the main circulating tank. In large plants where the amount of naphthalene is great, a centrifugal dryer is employed for the purpose of separating the small amount of oil remaining in the naphthalene, and also for reclaiming the naphthalene from the separating sump at the foot of the gas cooler. The crude naphthalene so obtained can be sold as such, or may be put into the tar in the coke plant.

The products obtained from the crude still will satisfy many commercial purposes in normal times. Moreover, at present the demands of chemical manufacturers for benzol and toluol of a high degree of purity have made it advisable to accomplish the complete process of purification at the coke plant to serve this important part of the trade. For this purification the crude benzols are first washed with sulphuric acid and then with caustic soda and water. This operation is accomplished in an agitator which is a large lead-lined vessel with an efficient mechanical mixing device for bringing the acid and benzol into intimate contact. The acid is commercial concentrated sulphuric acid (66 deg. Bé). The quantity used is accurately measured from the meter tank. The caustic soda solution is prepared in another tank and measured in a second meter tank.

The acid has the effect of reacting with and to a large extent polymerizing most of the impurities which consists of various olefines and substances of similar character, together with certain phenoloid bodies. This results in the formation of resinous substances of very high boiling point, part of which are insoluble in the benzols and settle out with the acid in the bottom of the agitator, while part go into solution, giving the benzol a dark brown or a reddish color. The acid sludge is drawn off and treated. The caustic soda neutralizes any traces of acid which may remain in the agitator and effect the removal of some of the phenoloid bodies. After the soda wash the benzol is a lighter brown color, but always requires distillation. The washed benzol is delivered from the agitator to the still. This still is generally of the same capacity as the crude still, but is provided with a very efficient dephlegmator. Sometimes purified products of less

exact boiling points are desired. In this case the washed benzols are distilled rapidly, simply to separate the benzol from the resinous materials in solution. The products so produced are termed "purified," e. g., 90 per cent purified benzol, 50 per cent pure benzol, etc., the nomenclature being based on the percentage in test distilling under 100 deg. C. The distillation for the preparation of pure products is conducted more slowly, the condensate being collected in receivers and tested carefully before placing in the final storage tanks.

Great improvement has been made in recent practice in the distillation of pure benzol and toluol. In a well-designed plant the cuts are remarkably clean and the percentage of intermediate fractions small. At one benzol plant pure benzene is regularly being produced of a grade such that less than 5 per cent distills below 80.1 deg. C. and 95 per cent per distills within 0.3 deg. C. Pure toluene also is being made, of which less than 5 per cent distills below 110.0 deg. C. and 95 per cent within 0.5 deg. C. This extraordinary degree of purity is of great advantage to manufacturers of explosives and synthetic chemicals requiring the use of pure benzols. The ease with which these distillations can be effected and the sharpness of the cuts obtained is very remarkable. Much of the secret of success lies in the correct design of the dephlegmator. The record of one plant shows the following average figures for the distillation of crude benzol containing toluene:

	Per Cent
Pure benzene	85.3
Intermediates	3.4
Pure toluene	9.8
Residue	1.3
Loss	0.2

The residue is often allowed to go to waste; but may be mixed with the coke-oven tar without injury.

The water and caustic soda used in the agitator are drained to the sewer. The acid sludge drained from the agitator is delivered to a boiler in which it is treated with direct steam. This effects a separation of the resinous materials in the form of a heavy carbonaceous spongy deposit. An acid of about 40 deg. Bé is recovered and may be used on the coke plant for making ammonium sulphate. The boiler is covered during the operation of steaming and the escaping vapors are condensed in a cooler.

The upkeep of a benzol plant costs remarkably little and the labor required in operation is small. A complete plant handling 5000 gal. of light oil per 24 hr. is operated by five men on day turn and three men on night turn, with two chemists for control testing and three laborers on day turn only for loading shipments and for general utility purposes.

The apparatus that is subjected to the most severe conditions is the superheaters. Spare superheaters should always be provided and the apparatus arranged so as to be readily interchanged. All apparatus for heating and cooling the wash oil should be so arranged that each individual unit can be taken out easily without disturbing the other apparatus. All apparatus with the exception of that exposed to sulphuric acid is made of iron and steel, no special alloys being required. It is very essential that the utmost precaution be taken in the arrangement of the piping to obviate the possibility of accidental mixing of the different products.

Since benzol is a by-product of coke and gas making, those

items in the cost of its production which are involved also in coke and gas production, are not chargeable to the benzol. In other words, the cost of making coke-oven benzol includes only the cost of its extraction from the coke-oven gas, and that of its purification. This cost in the United States will vary according to local conditions, but usually lies between 4.00 and 7.0 cents per gallon.

At the close of the European war, when prices again become normal, it will be possible with the large plant capacity then available to make a substantial profit from the production and sale of automobile benzol (90 per cent purified) at prices competing with those of gasoline. There are other large uses creating a demand for the various benzols, described in earlier paragraphs and further uses will be developed as the supply of the material becomes greater.

The effect of the removal of benzol on the calorific value

of the gas has been well worked out by J. W. Shaeffer, who recently published his results in an article read before the October, 1916, meeting of the American Gas Institute. The actual loss in the calorific value of the gas amounts to about 5.8 per cent, which is a figure representing the average practice of about thirty by-product coke plants. The figure agrees well with theoretical considerations. The result is that more debenzolized gas has to be used for accomplishing a given heating effect. Assuming that one ton of coal makes 11,000 cu. ft. of gas, a reduction of 5.8 per cent is equivalent to 638 cu. ft. less gas. As boiler fuel this gas is worth about 6 cents per 1000 cu. ft., so that the reduction may be figured to cost about 3.83 cents per ton of coal, i.e. about 8 per cent of the normal value (based on gasoline prices) of the total benzole recovered.

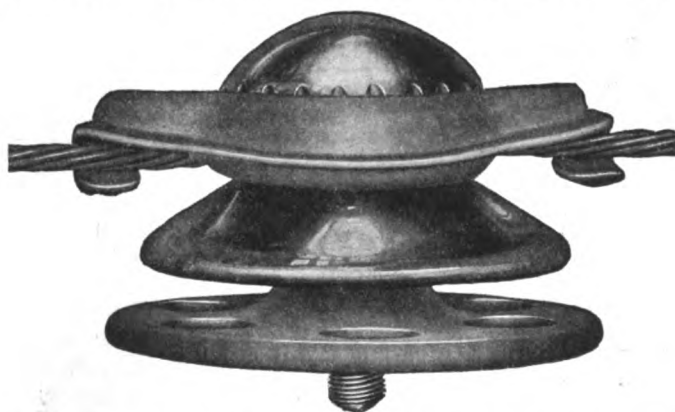
H. Koppers Company Laboratory, Mellon Institute, Pittsburgh, Pa.

WITH THE EQUIPMENT MANUFACTURERS

TROLLEY WIRE SUSPENSION FOR INDUSTRIAL PLANTS.

For the operation of electric industrial railways which must be capable of withstanding excessive temperature such as occur in coke, smelting and founding plants, special types of overhead line material must be used.

The General Electric Company, Schenectady, N. Y., has developed a special insulating suspension for trolley wires.



It is made of malleable iron, porcelain and cement, to meet these conditions, of high temperature and gives efficient service on voltages up to 600.

The Form P suspension, as it is known insulates the trolley wire from the cross span or bracket. It has a porcelain body into which a specially designed stud capable of withstanding a strain up to three tons is cemented. A malleable iron span yoke is provided for attaching to the span wire and a malleable iron wheel guard affords protection against "wild" trolley poles.

About a year ago there appeared in several of the technical journals an account of a test on a centrifugal pump installed at the low level pumping station of the city of Montreal, showing a duty considerably above any previously recorded for steam-turbine-driven centrifugal pumps. In answer to certain criticisms as to the method of figuring the duty, which was based upon the total heat taken by the turbine from the boiler, rather than the amount of steam used, and also regarding the omission of certain data from

the test report, an article has been prepared by A. Peterson, an engineer of the De Laval Steam Turbine Company, of Trenton, N. J., which the latter company has now reprinted and is distributing in booklet form. The use of net B.t.u.'s as the basis upon which to calculate duty is defended upon the grounds that the user is interested in obtaining the most foot pounds from a given amount of heat, rather than the smallest weight of steam. It is shown that a heat cycle which may appear more efficient upon the basis of steam used, may at the same time be the less efficient upon the basis of heat used. Users of steam turbines will be interested in the detailed analysis of the turbine performance.

The De Laval Steam Turbine Company, Trenton, New Jersey, manufacturer of steam turbines and helical reduction gears for all classes of service, including ship propulsion and marine work, centrifugal pumps, centrifugal compressors and similar apparatus, announces the opening of a district sales office in the Smith Building, Seattle, Washington, in charge of William Pullen.

We have received from the Whiting Foundry Equipment Company its catalogue No. 127, superseding No. 110, and their Watters bucket catalogue No. 126 (replacing former No. 104). These two catalogues show the most recent developments in the Whiting and Watters lines, and will be sent on request by the Whiting Foundry Equipment Company, Harvey, Ill.

The Coppus Engineering & Equipment Company, Worcester, Mass., has purchased property formerly owned by the Hill Drier Company, on Park avenue, consisting of nearly an acre of land, and two four-story brick buildings containing approximately 30,000 sq. ft. of floor space. The increased demand for the products manufactured by the company made it necessary to select larger quarters. The company also expects to manufacture another line of apparatus which will be announced later.

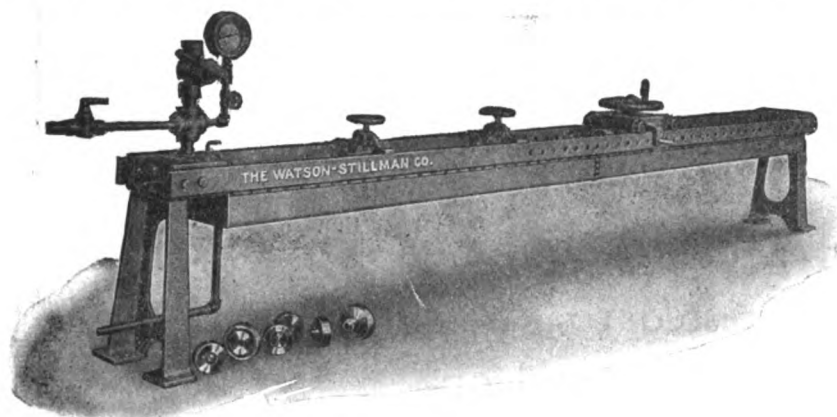
TUBE TESTING MACHINE.

The Watson Stillman Company, New York, has added to its line of hydraulic machinery, a new testing machine for subjecting boiler and other tubing to internal hydrostatic pressure. The machine is designed to be used either with a

hand or power driven pump, so that it is adaptable to shops of only occasional testing or for large capacity.

The machine consists of a frame with two rectangular tie bars, at one end of which is a stationary abutment; at the other end a moving abutment in the shape of a carriage mounted on rollers, which can be adjusted to the length of the tubes to be tested and then secured to the side frames by pins, and a high pressure hydraulic pump to subject the tubes to a predetermined internal hydraulic pressure.

The tube to be tested is placed in the machine with one end against the fixed abutment, the moving abutment is then brought to bear against the other end of the tube, pinned to the frame, and the tube is made pressure tight by turning the hand wheel. Two intermediate clamps operated



by small hand wheels prevent the tube from buckling while under pressure. The tube is then filled from water main, overhead tank or by low pressure pump. After the tube is filled, a high pressure hand or power pump is used to raise the pressure to the desired test, as shown on page.

There is a pan under the bed of the machine to catch the waste water which will serve also as a reservoir if a pump is used for the initial filling.

The machine illustrated is designed to test boiler tubes up to 4¼-in. outside diameter to a pressure of 1200 pounds per sq. in. The minimum opening is 5 ft.; maximum opening 15 ft. Weight of machine 2000 pounds. Other sizes to meet special requirements can be built, using the same general design.

The Crocker-Wheeler Company, Ampere, N. J., with its report for the first quarter of 1917, boosted the surplus fund to almost \$1,000,000. Dividends of the normal amount have already been earned on both common and preferred stock for the year, and a large amount has been distributed over equipment buying in the past few months.

According to the twenty-fifth annual report of the General Electric Company, the profit for the period ended December 31, 1916, amounted to \$15,294,091. The net income reached \$19,160,973. Orders received for electrical machinery and supplies were valued at \$167,169,058, an increase of 70 per cent over 1915. War munition orders amounted to \$2,416,000. Additions to manufacturing facilities cost \$8,828,254.

On the recommendation of President Waddill Catchings, the directors of the Sloss-Sheffield Steel & Iron Company, Birmingham, Ala., have voted to defer the quarterly dividend of 1½ per cent due at this time on the \$10,000,000 outstanding common stock. The earnings will be used in developing the properties.

INDUSTRIAL USES OF HYDRO-ELECTRIC POWER.

At the present time the steel mills of this continent are absolutely dependent upon the electric furnace for the production of alloys. The automobile manufacturer is dependent upon another electric furnace production, aluminum, for car bodies. The manufacturer of steel products needs these materials for making tools, and countless factories require abrasives which cannot now be imported, and which are now being produced in the United States, at any rate, only by electric processes. Without acetylene gas and graphite, and other electric products, many existing industries would be absolutely crippled.

So far as the products of electro-chemistry are concerned, it is found that the surgeon and the doctor look to electric plants for chloroform and disinfectants; the cotton and the paper manufacturer need the bleaches produced by electricity; the user of soap patronizes the electro-chemical establishment, as does every user of matches. Gold and silver mining of the west requires electric products to assure a profit, and it is only lately that the United States, cut off from its supply of German dyes, has found itself dependent upon electric products to supply the deficiency, in part at any rate.

These are but a few of the industries dependent upon cheap electric power. The further development in either Canada or the United States, or the inauguration of such processes in Canada, is very largely, if not altogether dependent upon cheap available, dependable power. The source of such power is admittedly, for a very large portion of our country, water-power. The development of water-power in making available a supply of cheap hydro-electric energy in various parts of the Continent would probably result in the reduction of the cost to the consumers of countless articles of every-day use, which, to the man on the street, are in no way associated with hydro-electric development.

Of the 2,000 employees of the Milwaukee plant of the Cutler-Hammer Manufacturing Company about 400 shop men are enlisted in the Naval Coast Defense Reserve. This enlistment is made under the plan provided in the new naval law and has not involved any interference with the progress of work in the shop. It is not expected that the ordinary operations of this company or other companies whose men have enlisted will be interfered with.

The Poole Engineering & Machine Company, Baltimore, has acquired, through consolidation, the exclusive manufacturing and selling rights of the turbo-gear manufactured by the Turbo-Gear Company, Inc., also of Baltimore. This is a device which, through long and severe service, has proved its great value for use with high-speed electric motors, steam turbines and other prime movers or driving machines that require a different speed for the driven unit. A descriptive catalogue has been issued by the company and will be sent on application.

The United States Steel Corporation plans to pay its income tax in advance, from earnings accumulated during the first three months of the year, the net earnings for the period being \$113,121,018. The Corporation plans to take at least \$5,000,000 in the new long-term bond issue in addition to aiding by anticipating payment of its income tax.

We have received Bulletin No. 501, dated March, 1917, from the Spray Engineering Company, 93 Federal street,

Boston, Mass., in which is given a condensed summarization of recent "Spraco" developments. The cooling system manufactured by this company is described and amplified by typical illustrations of other applications of this firm's products—including spray nozzles for binders for roads, asphalt, and other liquids that are difficult to atomize. The bulletin will be sent direct from the Spray company, or through application from this publication.

The Raymond Concrete Pile Company, 140 Cedar street, New York City, announces that it has secured contracts for the following steel plant construction:

Foundations of concrete piles for the 8-, 10- and 14 inch mills of the Donner Steel Company, Buffalo, N. Y.

A Raymond pile foundation for the by-products building of the Bethlehem Steel Company, Sparrows Point, Md., H. Koppers Company, engineers.

An approach trestle for the Bethlehem Steel Company, at their Steelton, Pa., plant.

The Hydraulic Press Manufacturing Company, Mt. Gilead, Ohio, has recently booked an order from a Russian firm at Petrograd for the building of five heavy hydraulic forming presses.

RECENT PATENTS

The following patents are reported expressly for THE BLAST FURNACE AND STEEL PLANT, from the patent law offices of Norman T. Whitaker, Legal building, Washington, D. C., (opposite United States patent office) from whom copies of any one of the patents may be obtained by sending 15 cents in stamps:

A process for sintering fine oxid ore and metallurgical products has just been invented by Heinrich Bittman, Frankfort-on-the-Main, Germany, patented as No. 1,221,962 and which is claimed as follows: The herein described process of treating metal oxid ores that are initially in a fine condition to form therefrom coherent, thin, agglomerated or sintered masses suitable for blast furnace treatment, its consisting in forming in superposed relationship to each other a layer of carbon fuel and a layer of the ore to be treated, causing the layer of fuel to actively burn under the influence of a current of combustion-supporting gas supplied thereto, thereby generating heat and producing carbon oxid gases, forcing the products of combustion from the said burning fuel layer and the gaseous bodies mixed therewith through the ore layer and causing reactions to take place among the metallic oxid particles thereof under the influence of the heat and the carbon oxid gases, whereby the ore masses are caused to cohere and form agglomerated masses. The inventor has assigned his rights to Dwight & Lloyd Sintering Company, Inc., New York, a corporation of Delaware.

Two patents have recently been granted to Isador Ladoff, Wilkesburg, Pa. One patented as No. 1,221,873 on a process of producing alloys, and the second, No. 1,221,874 on a method of making alloys. The first one is claimed as follows: The method of producing an alloy which comprises mixing the oxids of its constituent metals, incorporating with the mixture a compound the reducing temperature of which is lower than that of one of said oxids, and subjecting the charge, in a reducing atmosphere, to temperature below the melting points of said metals, but sufficiently high to inaugurate, and maintaining such temperature sufficiently long to insure reduction of said oxids. The second one is claimed as follows: The method of making high speed tool steel which comprises preliminary producing at a single heat, a quaternary alloy of ferro metal with tungsten, chromium and vanadium, and of which alloy the said tungsten, chromium and vanadium constitute, in their aggregate, not less than fifty per cent, and thereafter melting the said alloy in a bath of ferro metal not comprised in said alloy. The patentee has assigned thirty one-hundredths of his rights to Walter D. Edmonds, of Boonville, N. Y.

A patent, No. 1,220,416, has been issued to John Jefferson Gray, Jr., Rockdale, Tenn., on a process of making ferro-phosphorus, in which the following is substantially claimed: The process of producing ferro-phosphorus in a blast furnace which consists in charging the furnace with a suitable mixture of iron bearing material, phosphatic material, fluxing material and carbon; maintaining free uncombined carbon in the fusion zone of the furnace; maintaining a temperature in said fusion zone sufficient in the presence of said free carbon to reduce the phosphorus of said phosphatic material to the elemental condition; and maintaining such a top

temperature as will facilitate the entry of the phosphorus into the iron present, substantially as described.

Two patents have been granted to James H. Gravell, Philadelphia, Pa., on cleaning metals and preventing them from corroding. No. 1,221,441 is claimed as follows: A bath for cleaning metal and preventing it from corroding consisting of an admixture of calcium phosphate, sulphuric acid and water. Patent No. 1,221,442 has been claimed as follows: A bath for cleaning metal and preventing it from corroding, consisting of an admixture of calcium phosphate, an acid salt capable of reacting with the said calcium phosphate to form hydrocalcium phosphate, and water.

Otto Oesterlen, Zweibrücken, Germany, has just been issued a patent No. 1,219,852 on a process of preheating blast furnace gases. The gist of the invention is claimed as follows: The process of preheating the waste gases from blast furnaces for utilization in hot blast ovens, which consists in burning a portion of such waste gases and passing the products of combustion through a preheater through which the main volume of waste gases are passed.

A process of pickling metal articles, patented as No. 1,221,735, has been invented by Addison F. Hoffman and William M. Parkin, Pittsburgh, Pa., in which it is claimed that in the pickling of metals, the step of subjecting such articles to the action of a bath containing a scale-removing agent and a small quantity of neutralized sulfite waste liquor.

The following patents are reported expressly for THE BLAST FURNACE AND STEEL PLANT, by E. G. Siggers, patent attorney, Suite No. 31, National Union building, Washington, D. C., from whom copies of any one of the patents may be obtained by sending fifteen cents in stamps.

Addison F. Hoffman and William M. Parkin, Pittsburgh, Pa., have invented improvements in process of pickling metal articles, No. 1,221,735, dated April 3, 1917. This invention relates to pickling metal articles, for example, iron, steel and the like, either castings, wrought metal or any other variety of metal, and has particular reference to the preparation of iron and steel for coating with tin, zinc, enamel or the like. The process comprises neutralizing sulfite waste liquor with basic calcium compounds, removing insoluble matters, and thereafter adding a relatively small quantity of the same to an acid pickle.

William C. Coryell, Youngstown, Ohio, has invented improvements in rolling mill, No. 1,221,029, dated April 3, 1917. The present invention relates to rolling mills generally and more particularly to mills of the type employed in producing endless articles, such as belts, bands, hoops, etc., from rings or perforated pieces of metal. The mill includes boxes, a roll journaled in said boxes when in its operative position and removable transversely of its axis out of said operative position and out of engagement with said boxes, and a plurality of cooperating rolls for applying forces from a plurality of directions to cooperate with the force applied thereto by said boxes, to maintain said roll in proper operative position.

Steel Plant Incorporations and Construction

Rome, N. Y. — The Rome Merchant Iron Mill has been reincorporated as the Rome Iron Mills, Inc., and a large increase in facilities for the production of hollow iron will be put in, under the former management.

Warren, Ohio. — The Liberty Steel Company has recently been incorporated here by E. F. Clark president and treasurer; Albert Kenworthy, vice president and secretary; with these two and John W. Ford, T. A. Manchester, Howard Taylor and W. H. B. Ward, as directors. A sheet mill will be built here by the company in a short time.

Dover, N. J. — The Ulster Iron Works plans to begin the installation of its new rolling mill for the manufacture of bar iron and similar products shortly.

Cleveland, Ohio. — The Elyria Iron & Steel Company plans a new building at its Elyria, Ohio, plant, 180 x 200 feet in extent, in which will be installed rolling mill equipment and other finishing machinery.

Allentown, Pa. — The National Slag Company plans to move its general offices here from Philadelphia.

Seattle, Wash. — The Pacific Coast Steel Company plans to put in operation the Irondale, Wash., blast furnace of the defunct Western Steel Corporation. If this experiment is successful a modern stack will probably be erected.

Lorain, Ohio. — The American Sheet & Tin Plate Company has bought a site of 600 acres, but is understood to be holding the land for future expansion.

Homestead, Pa. — The Carnegie Steel Company will start work at once on a 110-inch plate mill adjoining the Howard Axle Works, and plans to have the mill ready for production within the next six months. Most of the work will be done by the Carnegie Company under its various departments.

Lebanon, Pa. — The Weimer Chain & Iron Company, Eighth avenue and Pennsylvania Railroads, has under way an addition to be 60 x 200 feet, and to house 14 new fires.

Carlisle, Pa. — The Frog Switch & Manufacturing Company, plans an addition as a means for enlarging its manganese plant.

Milwaukee, Wis. — The Modern Steel Casting Company has been formed here

for \$25,000, by A. J. Deuser, Fred W. Biehn and William T. Hardy.

Beaumont, Texas. — The Texas Rolling Mill Company plans to clean up the work at its new rolling mill here and will probably begin full tonnage production about June 1.

South Bethlehem, Pa. — The Bethlehem Steel Corporation has obtained license from the United States Steel Corporation for the installation of a six-ton Heroult electric furnace.

Pottstown, Pa. — The Pottstown Steel Plate Products Company, recently formed with a capital stock of \$50,000, has acquired a favorable site here for its plant and work will probably be started in the near future.

Baltimore, Md. — The Baltimore Tube Company, Wicomico and Ostend streets plans to add a one-story shop, 62 x 141 feet, to cost about \$10,000. The West Construction Company, American building, Baltimore, has the contract for the building.

Baltimore, Md. — The Hess Steel Corporation is having plans prepared for a steel furnace building upon which it is seeking bids.

Sligo, Pa. — Work has been resumed at the guide mill of the Sligo plant recently and repairs and renovations on the other sections of the plant are being pushed with a view to having the entire plant in operation as soon as the required supplies and materials can be secured.

Pittsburgh, Pa. — Hubbard & Company, announce the acquisition by purchase of the plant of the Hussey-Binns Company, Charleroi, Pa. This company has been operating its electric furnace recently with success.

Niles, Pa. — The Niles furnace of the Carnegie Steel Company, which has been down for repairs and on account of the coke shortage, has been put into shape and is again on the producing list.

Jersey City, N. J. — The Jersey Steel Company has been incorporated with \$125,000 capital to manufacture steel ingots and billets, by A. B. Shanahan, W. Turner and H. Cross.

New York. — The Bare Wire Company has been organized by J. S. Keith, E. F. Waterbury and E. W. Moore, 10 East Forty-third street, with \$500,000

capital to manufacture wire, cables and insulated wire.

Rome, N. Y. — The Rome Iron Mills Company has been incorporated with \$2,000,000 capital, to manufacture iron, steel and tools, by F. R. Series, A. R. Palmer and H. G. Wenzel, 2 Ferry street, Woodhaven.

York, Pa. — The American Chain Company has purchased a site adjacent to its plant and will build a three-story addition to its plant.

IRON AND STEEL QUOTATIONS COMPARED WITH PRICES OF A MONTH AGO

PIG IRON.			
Pittsburgh*—		March 26	April 26
Bessemer	37.95@	38.95	42.95@ 44.95
Basic	32.95@	33.95	40.95@ 42.95
No. 2 foundry ..	37.95@	38.95	40.95@ 42.95
Malleable	35.95@	36.95	40.95
Gray forge	32.95@	33.95	38.95
Ferro-silicon, 50% ..	250.00@	300.00	300.00
Ferro-silicon, 10% ..	53.00@	55.00	60.00@ 62.00
Ferro-mang., 80% ..	300.00@	350.00	425.00
Spiegeleisen, 20% ..	70.00@	75.00	75.00@ 80.00

* Pig iron prices quoted here are at Pittsburgh, with freight rate from Valleys to Pittsburgh, 95 cents added.

Virginia Furnaces—			
Basic	32.25@	32.75	35.25@ 37.25
No. 2X	35.50@	36.00	38.00@ 39.50
No. 2 plain	35.50@	36.00	37.50@ 39.50
Gray forge	30.50@	31.00	37.00@ 39.00

Philadelphia (del.)—			
No. 2X foundry ..	39.00@	40.00	42.50@ 43.00
No. 2 plain	38.00@	39.00	42.00@ 42.50
Basic	35.50@	36.00	38.00@ 40.00
Gray forge	33.50@	34.50	39.75@ 41.75

Chicago (at fur.)—			
No. 2 foundry ..	37.00		41.00
Malleable	37.00		41.00
Basic	37.00		41.00

Cincinnati (del.)—			
Northern No. 2 fdy	37.26		39.26@ 40.26
Basic	37.26		39.26@ 40.26
Nor. malleable ..	37.26		39.26@ 40.26

Birmingham—			
No. 2 foundry ..	30.00@	31.00	35.00@ 36.00
No. 3 foundry ..	29.50@	30.50	34.50@ 35.50
Gray forge	28.00@	30.00	34.00@ 35.00

STEEL.			
Tons of 2,240 lbs., at Pittsburgh.			
Bessemer billets ..	65.00@	70.00	75.00@ 80.00
Open hearth billets	65.00@	70.00	75.00@ 80.00
Forging billets ..	90.00@	95.00	100.00@ 110.00
Sheet and tin bars	65.00@	70.00	80.00
Wire rods	80.00@	85.00	85.00@ 90.00

FINISHED PRODUCT.			
Tons of 2,000 lbs., at Pittsburgh.			
Skelp, grooved ...	70.00		70.00
Skelp, sheared ...	75.00		110.00
Sheets, No. 28	100.00@	110.00	120.00@ 130.00
Galvanized sheets ..	125.00@	150.00	140.00@ 150.00
Shapes	72.00@	75.00	72.00@ 75.00
Plates	95.00@	105.00	110.00@ 120.00
Hoops	67.00@	70.00	80.00@ 90.00
Bands	75.00@	80.00	70.00@ 75.00
Steel bars	67.00@	75.00	70.00@ 75.00
Iron bars	70.00@	75.00	75.00@ 78.00

Per lb. on large orders:			
Tin plate	7.50@	8.00	7.50@ 7.75
Plain wire	3.25		3.55
Galvanized wire ..	3.85		4.15
Wire nails	3.20		3.50
Galvanized nails ..	4.20		4.25